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CONTENTS

Involvements in Research in Present Day Economic Entomology.....D. L. VAN DINE 1

Sulfa Drugs to Control American Foulbrood.....LEONARD HASEMAN 5

Influence of Soil Minerals on Insects.....LEONARD HASEMAN 8

Light-Trap Studies of the Clear Lake Gnat.....ARTHUR W. LINDQUIST AND CHRISTIAN C. DEONIER 11

Investigations at the Henry R. Carter Memorial Laboratory of the United States Public Health Service.....S. W. SIMMONS 15

Insect Pollinators of Alfalfa in California.....E. GORTON LINSLEY 18

Factors Involved in the Separation of *Macrocentrus ancylivorus* Cocoons from Tuber Worm Pupae.....CHAS. H. MARTIN AND GLENN L. FINNEY 29

Feeding Chemicals to Plants and Animals for Pest Control.....R. C. ROARK 35

Benzene Hexachloride to Control Cotton Insects....E. E. IVY AND K. P. EWING 38

DDT to Control Bugs That Cause Deformed Peaches.....OLIVER I. SNAPP 41

DDT and Its Effect on Fish and Wildlife.....CLARENCE COTTAM 44

DDT Emulsion Applied to Rice-Field Water to Control Mosquitoes.....C. B. WISECUP, WILLIAM C. BROTHERS, PAUL M. EIDE AND CHRISTIAN C. DEONIER 52

DDT Residual-Type Sprays as Affected by Light.....ARTHUR W. LINDQUIST, HOWARD A. JONES AND A. H. MADDEN 55

DDT to Control Household and Stored Grain Insects.....J. J. DAVIS 59

DDT to Control Hornflies and Gulf Coast Ticks on Range Cattle in Florida.....JOHN G. MATTHYSSE 62

DDT for the Control of the Horn Fly in Kansas.....E. W. LAAKE 65

An Effective Method of Controlling Codling Moth in Oklahoma Orchards.....F. E. WHITEHEAD 69

Timing Spray Applications to Control the Pecan Nut Casebearer..W. C. PIERCE 76

Azobenzene as an Acaricide and Insecticide.....ROBERT C. HARING 78

SCIENTIFIC NOTES:

Benzene Hexachloride to Control Bugs on Cotton.....W. A. STEVENSON and LOUIS W. SHEETS 81

Mosquito Collections at Army Installations in the Fourth Service Command, 1943.....STANLEY J. CARPENTER and ROY W. CHAMBERLAIN 82

Control of the Blueberry Bud Mite ..... John S. Bailey and A. I. Bourne 89
Collections of Mosquitoes on Parris Island During 1945 ..... George H. Bick 89
DDT and Hornfly Populations ..... L. M. Peairs 91
DDT to Control the Winter Horse Tick ..... H. E. Parish and C. S. Rude 92
Sulfur as an Aphicide ..... Dwight Isely and Floyd D. Miner 93
Editorial 95
Horticultural Inspection Notes 98
Spray Conferences 100
Proceedings, Fifty-seventh Annual Meeting, American Association of Economic Entomologists, Dallas, Texas 101
Official Roster of the Association 119
List of Members 121

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Involvements in Research in Present Day Economic Entomology

Presidential Address Fifty-Seventh Annual Meeting, American Association of Economic Entomologists

D. L. VAN DINE, *Washington, D.C.*

The affairs of this Association are necessarily concerned in some respects with those of other scientific organizations. I will mention first some of the involvements that affect the membership as a whole before discussing a few others that have a bearing on our research as individuals.

We take pleasure in meeting with the Cotton States Branch and with the Texas Entomological Society. Their hospitality is gratefully accepted. We regret that circumstances did not permit holding joint sessions with the Entomological Society of America. It seemed necessary, in justice to our widespread membership, to resume our schedule of regional meetings following the interruptions of war. A renewal of joint sessions with the Entomological Society of America will be anticipated.

There are several bills pending in Congress for the establishment of a National Research Foundation. The purpose of this legislation is national support for scientific research and development. This is a matter of great interest to this Association and steps should be taken to insure that research in entomology is not overlooked.

Professor Essig mentioned last year in his address as retiring president that he thought our relations with the American Association for the Advancement of Science could be greatly improved. He suggested that some action be taken in that direction. As a result the situation has been studied by our councillors to the general Association. We will all be interested in their constructive report. In connection with our own responsibility in the matter, we should recall that our Association was organized within the American Association for the Advancement of Science and that the general Association is the parent association. We find in Insect Life for September, 1889, under the title "The Association of Official Economic Entomologists," the following note of the first meeting: "In pursuance of the call issued by Mr. James Fletcher, president of the Entomological Club of the American Association for the Advancement of Science, a meeting of those interested in the formation of such an association as that described in the title of this note was held August 29 and 30 at Toronto, Canada." We cannot permit relations that have existed for over half a century to become a subject of indifference or neglect, either on our part or on the part of the American Association for the Advancement of Science. The general Association is the common meeting ground of all the sciences and our interests in so many fields of research other than our own require that we support the efforts of our councillors in maintaining good working relations with the parent Association.

In response to a letter from C. Chester Stock, Executive Secretary of the Insect Control Committee, National Research Council, I submitted to them the following list of some of the major problems in the field of economic entomology:

The possible value to agriculture of the insecticide materials and equipment developed for military purposes.

Continued search for new and better insecticide materials, particularly organic

materials that do not possess the undesirable qualities of metallic substances.

Some of the known insecticide materials should be retested against insects to determine their residual toxicity.

Continued research to further reduce the per acre requirements of insecticides for control, by improvements in formulations and in equipment and methods of application.

Studies to determine the normal physiology of insects as well as the physiological conditions produced by insecticides.

Extended research in taxonomy is urgent, since in insect control the identity of the species concerned is of first importance.

Wide ecological studies, to determine the factors that influence the distribution and abundance of insects.

The highly important work on foreign insect parasite exploration and introduction, necessarily suspended during the war, should be restored at the earliest possible date.

Further research is needed concerning the possible control of noxious plants by the use of plant-feeding insects, as illustrated by the work in California against the Klamath weed.

The research on organisms of disease pathogenic to injurious insects should be extended. The value of such work is demonstrated by the control gained in the mass production and distribution of the milky disease against the grubs of the Japanese beetle.

The effect of insecticide materials on beneficial insect parasites, predators, and pollinators should be determined. As an agricultural insecticide, DDT is capable of destroying insect parasites along with their hosts unless measures are developed to alleviate such hazard.

Advice was requested also on the ways in which the American Association of Economic Entomologists might cooperate with the Insect Control Committee of the National Research Council and I replied that this Association desires to cooperate with them but our present knowledge of their organization did not permit us to suggest the channels through which such cooperation might be extended. I advised that under similar circumstances this Association has appointed representatives to serve with agencies having mutual interests and requested their suggestion of the manner in which this Association might extend cooperation with the Committee. James I. Hambleton as our representative to the Division of Biology and Agriculture of the National Research Council, reported last year that entomology has not played an important part in the deliberations of that Division. It appeared to him that entomologists are not taking full advantage of the resources of the National Research Council. E. O. Essig, in his report to the Entomological Society of America (Annals, Ent. Soc. Am., June 1945) as their representative to the above Division, refers to the Bi-monthly Report of the Division of Biology and Agriculture (Vol. 3, No. 4, April 1945) having among topics for discussion one entitled "Symptoms of Enlarging Opportunity for Public Service by Biologists and Agriculturists." Under this heading was a topic entitled "Insect Control" in which the great interest in DDT was presented. Professor Essig further reported that a coordinating committee in the broad field of insect control was named by the presiding officer of the Executive Board of the Division "in order to study this material in connection with the needs of war, agriculture, fish and wild life, public health and other phases." Professor Essig said that the interesting thing about this committee is that not an entomologist was named thereon and he rightfully protested such action. He further remarked "The entomologists of America are a well organized and fully recognized scientific unit, and have shown, especially in the research work done with DDT, that they are by far the most capable judges of the use of this material in the control of insects affecting agriculture, human health, and the armed forces of the country."

Further information may be forthcoming concerning the organization of the Committee on Insect Control of the National Research Council, with their suggestion as to the manner of extending cooperation to them.

Research in many fields of science other than our own are involved in the determination of measures for insect control in order to provide the broad basis that is necessary for practical control recommendations. We all appreciate that investigations relating to the development

of insecticides are interlocked with chemistry. A good illustration of this involvement is the special attention being given at this time to the possible value of DDT (dichloro diphenyl trichloroethane) for agricultural uses. The use of any insecticide material for the protection of agricultural crops presents an entirely different problem in comparison to its use for military purposes. DDT offers no exception. An immense amount of work was accomplished by entomologists working with insecticide chemists in the development of DDT for military purposes, and by chemical manufacturers in making available quantities of the product. The report of the special committee on DDT last year at the New York meeting brought out the time factor involved in developing satisfactory mixtures for agriculture. This problem of formulations is encountered in the development and testing of all new materials and is greatly advanced when there is close alliance between the entomologist and the chemist. When extensive experiments are carried on with any insecticide, we have found that still more rapid advance can be made by the use of material from a common source and of the same mixture as a standard of comparison in each series of tests.

The great need for new and better insecticide materials is well illustrated in codling moth control. Arsenical compounds have been and are the standard remedy for this insect. Slingerland in 1899 reported that in 1878 a practical fruit grower accidently discovered that when he sprayed his trees with Paris green, he not only rid the orchard of canker worms but that the apples on the sprayed part were much less eaten by codling moths. Cook first tested an arsenical against the codling moth in Michigan in 1880, using London purple. Today it is estimated that for spraying apple trees, chiefly to control codling moth, more than 40 million pounds of lead arsenate are required annually. Lead arsenate has the advantages of availability, low cost, effectiveness against leaf feeding insects as well as the codling moth, and compatibility with other materials but also has all the disadvantages of a metallic poison.

The search for new and better insecticide materials involves not only the chemist and the entomologist but also research specialists in other fields. The plant pathologist is concerned with these materials when used in combination with fungicides and the pharmacologist is interested in the possible hazard of any residues of the insecticide to human health when used on food crops. The interests of both the plant physiologist and the soil scientist are also involved in the development and use of insecticides. There is evidence that accumulations of arsenical compounds in orchard soils may become injurious to plant life. Snyder (1935) estimated that six spray applications using 2 pounds of lead arsenate per 100 gallons of water, with 35 trees per acre, applying 40 gallons of the mixture per tree per application, would result in an addition to the soil of 168 pounds of the chemical per acre per annum. Apparently the arsenic residue in the soil does not penetrate beyond the depth to which the soil is stirred by the cultivating implements. Vandecaveye, Horner, and Keaton (1936) found that following plantings in land from which old apple trees had been removed, alfalfa and barley showed poor conditions of growth.

Several branches of engineering are involved in research for insect control. The help of the civil engineer has been necessary in mosquito control where surface drainage is indicated and where water has been impounded. Electrical engineering plays an important part in response work with lights in providing sources of light and experimental equipment. Mechanical engineering has made possible the recent advancement in equipment for the application of insecticides. Further improvement along this line is needed since equipment and methods for the application of insecticides are far behind the materials themselves.

The work of the entomologist on the incrimination of insect vectors of plant virus diseases is intimately involved with the work of the plant pathologist. In the preliminary work to determine suspect species to serve as test insects, close cooperation is necessary to delimit the areas where infection occurs and to obtain the incidence of disease in those areas. In the transmission tests the identity of both the virus and insect experimental material must be assured. In addition to the identity of the insect material, the entomologist is responsible for the methods of rearing and manipulating the test insects

and for the prevention of contamination throughout the rearing and testing period. The plant pathologist is responsible for the source and identity of the virus material to be used and for the maintenance of a supply of healthy and diseased host plant material to be used in the tests. Team work is also required following transmission tests. It remains for the entomologist to furnish the information on the exposure of the test insects to the plant material and to verify the identity of the species of insects used and for the plant pathologist to diagnose the results in respect to infection. Should the evidence point to a recognized virus having been successfully transmitted by a certain species of insect, the results should be subject to confirmation. It is very important that cultures of the source of the virus be maintained by the plant pathologist and that stock of the test insects be available from the entomologist. The mutual interests of the plant pathologist and entomologist can be advanced to best advantage by a cooperative effort and a better basis for the control of the virus diseases of plants will result.

Entomologists should consider very carefully the possibilities in insect control that involve bacteriology. In biological control we think usually of the insect parasites and predators. More work has been accomplished and effective results obtained by the utilization of those natural enemies. The use of entomogenous fungi has not been so productive in results. This is probably due to the requirements of parasitic fungi in the matter of moisture and temperature favorable for their development. Bacterial organisms pathogenic to insects have been known for a long time, notably diseases of the silkworm and honey-bee. Until recently there has been no important development in their use for the control of injurious insects. The late Vernon Kellogg mentions (1892) one bacterial form, *Micrococcus insectorum* Burrill, in connection with the early use of fungi against chinch-bugs in Kansas to protect cereal crops. I would like to quote Kellogg's conception of the use of diseases against the chinch-bug. He says, "The remedy is effective for the same reason that if, in time of war, enemies were to send into a large city, as New York, men sick with the small-pox or Asiatic cholera, the infection would rapidly spread among the massed people of the city and wholesale destruction of life would result. So with the chinch-bugs massed in Kansas cornfields, when dying and dead bugs bearing with them the germs and spores of contagious diseases are introduced." This vision takes on some significance in the light of results that are being obtained in the control of the Japanese beetle following the development, mass production and distribution of the milky disease against the grub in the soil. We can only speculate what might have developed from the early work with chinch-bug diseases in Kansas if Kellogg had been working with a bacteriologist. There is an interesting problem in connection with the production of the milky disease spore dust material. At present the only known medium of culture of the organism is the living body of the grub of the beetle host. This problem in insect pathology invites the attention of the bacteriologist. If a means could be developed to produce the spore material in an artificial medium, it would be of the greatest value in the further control of the Japanese beetle, but more far reaching in its effect would be its value in culturing disease organisms specific to other insect pests.

A very promising line of research, involving both plant and insect studies, is the control of noxious plants by the use of plant-feeding insects. This line of investigation is illustrated by the early work against lantana in Hawaii, and against cactus in Australia, and by the present work in California against the Klamath weed, *Hypericum perforatum*. The objective to be gained is of course weed control, but the entomologist should not overlook the possible value in weed control of destroying by this method non-economic plants which serve as alternate hosts of insect pests.

Many other sciences involved in the different phases of insect control must be included in our research if we are to maintain a well balanced program. We all appreciate the cooperation that is indicated in the fields of physics, horticulture, agronomy, plant breeding and ecology, to name a few of the more important subjects in addition to those I have mentioned. Illustrations of the research needed in these sciences will occur to all of us.

In order to insure continued improvement in a scientific basis for insect control measures, we must do more than recognize the fields of research that have interests common to our own, we must enlist the necessary cooperation. Effective cooperation involves not only joint action in work but cooperative planning for work.

There is no part in the existence of man that is not influenced by insects. To hold supremacy against their domination we must be audacious in the development and application of suppressive measures against injurious insects and alert in the protection of the beneficial ones. If the problems of insect control were less involved and confusing they would have been solved long ago. There is no sovereign remedy for the control of any one agricultural insect pest. There never will be one particular remedy for the multitudinous and involved problems that confront us in insect control.—12-6-45.

Sulfa Drugs to Control American Foulbrood[1]

LEONARD HASEMAN, *University of Missouri, Columbia*

All are familiar with the ravages of the ailment of bees commonly known as American foulbrood. Most of you have probably seen it wipe out whole apiaries and make beekeeping in many communities a liability rather than an asset. It means to honey production about what hog cholera once meant to pork production or Texas fever to dairy and beef production here in the South. However, both of the latter menaces have been successfully met and from our results with the use of sulfa drugs I am convinced that foulbrood is definitely on the way out as a menace to beekeeping. Even should we in Missouri seem a bit over-enthusiastic, a thousand representative beekeepers, from the Atlantic to the Pacific, and from the Gulf to Saskatchewan can hardly all be wrong. Of the hundreds of beekeepers, small and large, who have used the treatment during the past summer, not one who has been able to give his bees a complete treatment with the drug has reported failure to get substantially the same results as we have reported. The treatment, in fact, is simply too good to be true and I do not blame anyone for being skeptical where he has not tried it out.

You are thoroughly familiar with the commonly recommended burning method, and many of you have probably used the formaldehyde and the chlorine treatments. Also, many of you are participating in the use of resistant strains. In our 30 years experience with bee diseases we have used all of these controls, in fact our department, in 1916, I believe, first announced the resistant strain theory after finding in our apiary colonies which actually cleaned badly infected combs and used them for rearing healthy brood. However, it has been our experience that none of these treatments is adequate to protect beekeeping in communities where American foulbrood infection is widespread, and particularly in years favorable for its dissemination.

As a result, 4 years ago we began, at first on a limited scale, the feeding of sulfa drugs as a possible cure for and protection against American foulbrood. The feeding of drugs to bees was not original with us, but I believe ours was the first systematic and successful use of a sulfa drug for controlling this disease of bees. L. F. Childers, a successful beekeeper and former soil chemist on the College staff, and the writer, first laid out plans for the experiment in the early spring of 1942. On the advice of Dr. Perrin H. Long, of the Johns Hopkins medical staff, and members of our own medical school, relative to dosages and procedure, we decided first to test possible toxicity of the drugs when fed to bees in varying amounts and concentrations in sugar sera. The experiments were begun in the department apiary in the spring of 1942 and later in the summer extended to include a number of colonies in the Childers

[1] Missouri College of Agriculture Journal Series No. 1000.

apiary. Sulfanilamide was used first in concentrations varying from 10 milligrams per cent to 200 milligrams per cent solutions, including at first only about a quart to a feeding. While the higher concentrations showed only slight evidence of toxicity to the bees we soon learned that the lower concentrations were entirely adequate. In 1942, we also checked sulfadiazine and sulfathiazole and found the latter definitely the most effective of the three drugs.

The 1942 results, while not satisfactory, convinced us that we were on the right track. Every colony receiving sulfa drugs, and especially those receiving sulfathiazole, responded with increased vigor, improved colony morale and definite improvement in the brood, some colonies completely clearing their combs of all evidence of infection. Plans were made for greatly enlarging the scope of the experiment in 1943. However, an obstreperous sciatic nerve and a shortage of help and sulfa drugs seriously upset these plans. As a result, we succeeded only in somewhat refining methods of feeding sulfathiazole and in determining the most desirable concentration to use. A half-gram tablet to a gallon of sugar sera, or approximately a 15 milligrams per cent solution proved adequate and safe and convenient to use. In the later large-scale feedings this concentration was used mostly. Also, a similar concentration in thick sugar syrup was used in preparing pollen substitute.

The 1943 results not only confirmed our 1942 findings but gave added evidence that sulfathiazole when properly mixed and fed was perfectly safe and effective in controlling American foulbrood. As a result, in the winter and early spring of 1944 we made plans to include 50 new packages and some 30 overwintered colonies showing varying degrees of infection in the Childers apiary and all the colonies in the department apiary. The colonies and packages were so arranged that a number of different experiments could be carried out independently or in combinations as follows:

(1) Packages of bees hived in used equipment and exposed to AFB infection in the same apiary and in neighboring apiaries were fed sulfathiazole both in pollen substitute and in sugar syrup to see if they could be protected from the disease.

(2) Packages exposed to these same dangers and given combs of honey stored by colonies which died of AFB the previous fall were fed sulfathiazole in syrup and pollen substitute to see if they could be kept free of infection.

(3) Swarms were hived on combs, of which some were reeking with infection in the form of decaying grubs and dry AFB scales, and fed the sulfathiazole in both syrup and pollen substitute to see if they would clean up the combs and rear healthy brood.

(4) Overwintered colonies of varying strength showing varying numbers of decaying grubs and dried AFB scales in their combs were fed both treated pollen substitute and treated syrup to see if they would clean up their combs and rear healthy brood in them.

In these experiments all colonies, packages and swarms were given pollen substitute containing sulfathiazole at the rate of a half gram to a gallon of thick sugar syrup used in making the pollen substitute. The same concentration of sulfathiazole in thin sugar syrup was fed to the packages, swarms and colonies. The amount of treated syrup given to each colony varied from 4 or 5 quarts up to about 8 quarts containing a total of 1 gram of sulfathiazole in the more severe tests. The feeding of the treated syrup extended over periods varying from about 40 to 60 days in most cases. The treatment was given its severest test in case of those overwintered colonies and swarms which were required to clean up from two to half a dozen or more badly infected combs. In fact, some colonies were so heavily loaded with diseased brood at the beginning of the spring feeding that we did relieve them of some of the worst combs and much of their surplus honey.

The experimental colonies were checked at intervals to determine the progress they were making in clearing up the infected combs and in filling them with healthy brood. The colonies required 3 to 6 weeks to clean up the worst combs and, in most cases, within 30 days the combs would be well stocked with healthy brood in different stages of development. Invariably as soon as the cells were cleaned and the foul odor was removed from the combs the queen would begin using them. Also, it was rare to find a single new grub show-

ing signs of infection after the queen once began to oviposit in a cleaned-up comb.

By early July every experimental colony receiving the sulfathiazole was free of all evidence of infection, the hives were running over with workers and each colony stored a goodly crop of surplus honey. In the fall (1944), when prepared for winter, there was still no sign of infection in any of the colonies. A careful checkup last June and again this fall still shows no signs of disease in these experimental colonies despite the fact that sources of infection were available in the neighborhood and some wild swarms coming to the apiary promptly developed signs of disease before being fed sulfathiazole. During the spring and summer of 1945 most of the 80 experimental colonies received no further feedings of sulfathiazole. The 1944 results were so perfect that we felt we owed it to at least our Missouri beekeepers to tell them about the sulfathiazole treatment, since we have had no provision for official bee disease inspection and control work for the last 10 years. Our findings given in Missouri Agricultural Experiment Station Bulletin 482 is a report of progress rather than a completed thesis on the subject.

During the spring and summer of 1945 we repeated the tests with sulfathiazole and also carried out a small experiment including four colonies to which sulfaguanidine was fed at the rate of one gram to a gallon of syrup. Sulfaguanidine is easier to mix with the sugar syrup and it has shown evidence of being as effective as sulfathiazole, for the treated colonies promptly cleaned up their combs and filled them with healthy brood. British beekeepers report similar results with sulfapyridine.

In the 1945 sulfathiazole experiments 3-pound packages of bees were hived on four to six of the worst AFB infected combs we could find and in 30 days they had cleaned up most of the combs and were beginning to rear healthy young brood in them. They received a total of 6 to 8 quarts of syrup with a half-gram of sulfathiazole to each gallon of syrup. In 60 days they had the combs cleaned and well filled with healthy brood.

Our plans for 1946 call for further study of sulfa drugs, including some water-soluble forms, also penicillin and other new bactericides, to determine whether or not even more effective drugs may be found. Also, we plan to include in the studies further checkup on the apparent effectiveness of sulfathiazole on Nosema. We also plan to work with European foulbrood and pickle brood, both of which diseases some beekeepers have reported as not being affected by the sulfathiazole treatment. Also we want to determine if possible just how the sulfa drugs work. We are interested also in determining if there may be an unsuspected relationship between Nosema infection of adult bees and AFB infection of the brood.

CONCLUSIONS AND RECOMMENDATIONS. —Our experience convinces us that sulfathiazole fed either in sugar syrup or in pollen substitute is an effective control for American foulbrood. It can be used either to prevent colonies from becoming infected or for enabling infected colonies to clean up their combs and rear healthy brood in them. Our results indicate that a thorough cleanup of a colony may protect it against reinfection for two seasons, but we would advise feeding the drug each spring and fall or whenever infection appears as a part of the regular apiary routine.

To use it, disperse one-half gram of sulfathiazole powder or a finely crushed half-gram tablet in a cup of hot water and add it to a gallon of sugar syrup for feeding in the usual way or for use in preparing pollen substitute. Four to 8 quarts of treated syrup containing one-half to one gram of sulfathiazole costing about a cent should be sufficient in most cases to protect a colony from infection or for enabling it to clean up infection. In severe cases, it will pay to relieve colonies of their worst combs, rendering them, and replacing them with full sheets of foundation or drawn combs. In small apiaries, feed the syrup and treated pollen substitute to the individual colonies in the usual way, but in large apiaries which include several hundred colonies it is better to feed the treated syrup in 50 or 100 gallon vats in the open yard and of course guard against starting robbing. Neighbors' bees will carry away some of your syrup but in return it will help to rid their colonies of disease.—12-13-45.

Influence of Soil Minerals on Insects[1]

LEONARD HASEMAN, *University of Missouri, Columbia*

Entomologists are not unmindful of the fact that the health and well being of man and beast depend on a proper diet which includes the required mineral, growth and energy producing elements. Also, it is well known that foods grown on mineral deficient soils may lack some of these elements and if they are not supplied in pills, concentrates or otherwise in time, serious impairment of health may result. The wide demand for whole wheat flour from the mineral rich Deaf Smith County soils here in Texas and the fact that some authorities question the nutritive content of the so-called "protective" foods supplied to the great eastern cities from mineral-deficient eastern seaboard soils further stress this point. Also, commercial advertisements and daily radio announcements constantly warn of such dangers. Some soil specialists in fact have even gone so far as to warn of possible future doom to the human race through "hidden hunger" resulting from the consumption of foods grown on soils deficient in the essential minerals. If man does not call a halt to the losses from erosion and robbing of the soil by faulty cropping, they warn, such a fate may await him.

Insects being animals, it would seem logical to expect that they too might be affected by mineral shortages and other deficiencies in their food supply similar to man and livestock. As a result, some years ago we laid out a project designed to find out just what does happen when different species of insects are reared on plants grown on nutrient solutions deficient in any of the essential soil minerals. When we began the study we fully expected to find some impairment in their health, vigor and power to reproduce when reared on crops grown on mineral deficient soils. We were surprised to find, therefore, in some of our earlier experiments that our insect "guinea pigs" were seemingly not handicapped to any extent if at all when reared on plants grown on mineral deficient soils. We attempted to explain these unexpected findings to ourselves as being due to insects' great power of adaptation or possibly to the fact that the test insects being very small might have secured adequate quantities of the deficient minerals even though we had completely withheld them from the nutrient solutions supplied to the plants. Later however, as the investigations progressed, any such explanation seemed inadequate for we began to find that a shortage of certain minerals actually proved beneficial rather than harmful to some of the test species. For instance, the chinch bug and the greenhouse thrips both were found definitely to prefer and to thrive better on plants grown on a nitrogen deficiency. We certainly were not prepared to expect this even from such unpredictable creatures as the insects. These findings were the exact opposite to those generally reported for man and other experimental animals on a mineral deficient diet.

In these investigations we have so far included the grain aphid, chinch bug, greenhouse thrips, greenhouse white fly and the Colorado potato beetle. Much of this work is still rather exploratory in nature. However, we feel that our findings should be reported at this time, if for no other reason than to encourage some of you younger men to undertake similar investigations. As I shall point out later, we have gone far enough to feel justified in hazarding a theory on insect abundance which possibly may radically change our whole scheme of controlling insect pests in the future.

From the one series of experiments with the Colorado potato beetle reared on plants grown on different mineral deficiencies we have been unable to draw definite conclusions, though we did find variations in rate of maturity and mortality. Each species of insect seemingly has a very definite nutritional requirement to satisfy though, as in case of the potato beetle, it may suddenly change that requirement or at least the botanical source of that requirement. From our findings along this line it would be a safe guess, and we aim to try to prove it, that when the Colorado potato beetle moved over from the wild nettle to the potato plant it found a new, more favor-

[1] Missouri College of Agriculture Journal Series No. 999.

able combination of plant nutrients which simply changed it from an insignificant weed feeder to a revitalized nationwide menace to one of our most important crops.

Our data on the greenhouse white fly is from a single experiment with limited replications but this winter we have a much larger experiment set up. In this year's experiment we are studying the effect of different levels of only three minerals, calcium, nitrogen and phosphorous. Our last year's data on the white fly indicate that on petunia plants it thrives best on those grown on full nutrients and a shortage of either iron or potassium makes plants unsuited for normal development. On the other hand, in case of tomatoes the data indicates that plants on full nutrients are less attractive than those on either a phosphorous or a magnesium deficiency. In these experiments some plants were grown on full nutrients while the other test series were grown on full nutrients minus one of the minerals calcium, potash, nitrogens, phosphorous, magnesium or iron. In some of our experiments we cage definite numbers of insects on the test plants and keep individual records on their performance while in other experiments the insects are allowed to disperse from a common reservoir and choose the plants they prefer.

Our investigation of the reaction of the common grain aphid, *Toxoptera graminum* to mineral shortages has been much more extensive. In 1940 W. K. Delaplane, Jr., while doing graduate work, reared 12 generations of the grain louse on wheat plants grown on full nutrients and on seven parallel series of plants grown on full nutrients minus either calcium or nitrogen or phosphorous or potash or magnesium or sulfur or iron. In his experiments he found that while the aphid bred more uniformly on full nutrients, shortages of either sulfur or potassium or magnesium or phosphorous had no apparent ill effects on them, and for the first six generations the individual aphids actually produced more offspring on the average than did those on the full nutrients. In case of major outbreaks of this pest it is usually during the first month or the first few life cycles that most of the damage is done. Thereafter parasites and predators come in for the kill. Here therefore, is a species which in nature may actually be stimulated to greater crop destruction on land showing deficiencies of one or more of these particular soil minerals. In case of either iron or nitrogen deficiencies the pest simply failed to make any headway and succeeding in producing but few offspring and survived for only a few generations.

In 1942 we duplicated some of Delaplane's experiments carrying the grain louse through seven successive generations. In these experiments a nitrogen deficiency again had serious effects on the well being of the louse, while the absence of either calcium, phosphorous, potassium or magnesium caused no very serious ill effects on the aphids. The rate of maturity of the individuals, however, was slowed down by the withholding of either of these minerals. For instance, aphids reared on plants grown on full nutrients matured and began producing offspring in 232 hours on the average for the first seven generations. In case of calcium deficiency the average was 272 hours, for potassium 284 hours, for phosphorous 297 hours, for magnesium 306 hours and for nitrogen deficiency 327 hours. Also in these experiments the average number of offspring for the first four generations was reduced being 33 on full nutrients, 32 on calcium deficiency, 26 on phosphorous deficiency, 25 on potassium deficiency, 19 on magnesium deficiency and 13 on nitrogen deficiency. From these data it would seem that it requires ample nitrogen in its diet. On the other hand it would seem that when either calcium, phosphorous or potassium was withheld from the nutrient solutions the aphid bred almost as well as where the plants were on full nutrients.

In case of the chinch bug Dr. Phillip C. Stone has found among other things that it thrives and matures faster, lives longer and produces more offspring when nitrogen is withheld from the nutrient solutions on which corn plants are grown as food. In nature the same thing is seen where chinch bugs are always found breeding heaviest on corn or small grain crops up along the thin, eroded hillsides rather than down at the foot of the slopes where the fertile top soil from the hill collects. We have usually explained this on the ground that the chinch bug is a lover of warm, sunny, dry surroundings when in

reality the pest is probably there because it craves plant sap low in nitrogen. For this same reason presumably it never attacks legumes. Corn planted with soy beans is less severely attacked by the pest due more to a stepping up of nitrogen in the soil and probably also in the corn sap rather than to the shading.

Here then we have a major pest which seems clearly to be benefiting by intensive farming resulting in a continual robbing of the soil of its nitrogen supply. While the buffalo and also cavalry horses thrive better on the native western grasses grown on mineral rich soil, it was not until the farmer began mining these soils by growing wheat, corn and other crops which draw heavy on nitrogen that the chinch bug really became a menacing scourge. In the last 100 years our major outbreaks of the pest have always appeared during series of dry seasons when crops actually draw less heavily on the soil minerals including nitrogen. We have been inclined to attribute these outbreaks to dry warm seasons which favor this insect when in reality the favorable low nitrogen content of the crop sap probably has more to do with chinch bug abundance than does the warm, dry weather.

Our study of the reaction of the greenhouse thrips to nitrogen and calcium shortages was rather accidental. Last spring Dr. Wittwer of our horticulture department observed insect damage to some of his pots of young New Zealand spinach plants grown in the greenhouse on varying levels of calcium and nitrogen in his study of soil minerals and vitamins. The soil in all of the 160 pots was prepared especially and it contained the same amounts of all the essential soil minerals required for normal plant growth except for nitrogen and calcium. Four different levels of each of these two minerals or sixteen different combinations of the two minerals were included in the experiments. We were called in to control the pest but much to our surprise we found a perfect setup for observing the reaction of the culprit, the greenhouse thrips, to calcium and nitrogen deficiencies. Dr. Wittwer gladly joined us and set aside one complete replication or 80 pots of plants for the thrips study while we treated the other half of the experiment with DDT to check insect damage. The thrips were found to be breeding on a small weed under the greenhouse tables so they were allowed to simply choose the particular pots of plants they preferred most. They began attacking the young plants before they were two inches tall.

The first thing we observed on checking the plants was the fact that the thrips were attacking only those plants growing on the lower levels of nitrogen. Apparently the calcium played no important part in making the plants attractive to the thrips. Practically every plant in every pot in the two lower nitrogen levels were attacked, some so seriously as to be almost killed. On the other hand, scarcely a plant on the two higher nitrogen levels showed any signs of thrips injury. This was the most perfect picture of insect response to a mineral deficiency we have yet seen. For some reason the thrips consistently avoided the larger, deep green plants growing on the two higher nitrogen levels. Here then, as in case of the chinch bug is an insect naturally adapted to satisfy its nutritional needs by passing up nitrogen rich plants and feeding on the nitrogen starved plants. Actually the plants which the thrips avoided were the luxuriant kinds generally available on the market for human consumption.

As the crop of spinach matured and began to bloom we found that the thrips moved up from the lower nitrogen levels to the plants on medium level of nitrogen with some few plants on the high nitrogen level showing some damage. What seemingly happened here was the storing of some nitrogen in the developing seed thus lowering the level of nitrogen in the foliage of those plants on higher nitrogen levels sufficiently to make them attractive to the thrips. In like manner, seemingly the transfer of nitrogen to the seed in case of the injured plants on low levels of nitrogen so reduced the nitrogen in the foliage that the plants were less attractive to the thrips. We are now duplicating this cooperative experiment on a considerably larger scale to see if we can determine more closely the optimum level of nitrogen in the foliage of this plant for the greenhouse thrips.

The plants from each of the 80 pots in both replications were analyzed for Vitamin C, oxalates and minerals and the ones which the thrips selected were the lowest in nitrogen and the highest in

phosphorous, oxalates and Vitamin C. This might raise the question as to whether it was the low nitrogen or the high vitamin and phosphorous content of the plants that actually attracted the thrips. Be that as it may, it was the plants grown on soils with low nitrogen levels that attracted them. It is on this point supported by our studies of the chinch bug, aphid and white fly and by common field observations familiar to all of you that we hazard this explanation for the fact that our insect pests continue to become worse as years go by even though we do make some improvements in our standard control methods. As with the higher animals for optimum development and reproduction each insect has its specific nutritional requirement which according to these findings would seem to vary greatly so far as minerals are concerned, from those of man and other vertebrates. The indications are that insects require less of minerals and that they may actually thrive best on shortages of certain minerals. We shall probably find that the different crop pests will vary as to which minerals they require in reduced amounts. However, it would seem that by lowering the total level of soil minerals through erosion, overcropping and faulty crop rotation we are systematically improving conditions for our insect pests while making them less and less favorable for our crops, livestock and ourselves. If there is real danger that the loss of soil minerals may spell the doom for the human race it looks as if this same depletion of soil fertility may also be making it more certain that insects will the sooner supplant us.

If these conclusions are correct, then we economic entomologists should begin to think and do more about fighting insect pests through the soil and perhaps begin to depend less on the spray gun, fog machine, airplane and DDT. Not that we should let down on our chemical warfare but if our farming operations are actually developing bigger and better insect epidemics, then we should incorporate more soil conservation in our over-all plan of insect control.—1-7-46.

Light-Trap Studies of the Clear Lake Gnat

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The Clear Lake gnat, *Chaoborus asticto-pus* D. & S., which breeds in Clear Lake, California, is attracted to electric lights in such enormous numbers that it becomes a nuisance to residents living near the lake. Studies of flight, oviposition, and hatching of this insect (Lindquist & Deonier 1942) showed that huge concentrations of adults frequently occurred at the edge of the lake, and that from 50 to 90 per cent of them were gravid females. The attraction of the pest to lights suggested that light traps could be used, not only to reduce their abundance but also, perhaps, to reduce breeding. Herms & Burgess (1928) described a simple light trap, which, although small and comparatively inefficient, established the fact that gnats could be caught in such a device.

The principle of a suction produced by an electric fan was utilized in many types of traps that were designed and tested from 1938 to 1941, inclusive. The present paper deals with experiments on the efficiency of lights of various intensities and wavelengths in attracting gnats.

METHODS.—The tests were all conducted a few feet from the water along the northeastern shore of the lake, near the villages of Nice and Lucerne. The traps were suspended from poles so that the lamps were about 6 feet from the ground, which is the best height for attracting these insects. Usually only two traps were compared at one time in a given location, and they were spaced 20 to 30 feet apart so as to minimize the effect of location differences. The traps were operated during the evening flight, or for about 90 minutes each night, and were rotated at regular intervals.

Tests with filament lamps were made in traps consisting of a metal cylinder (12 to 18 inches diameter) in which an electric fan was suspended. The lamp was fitted above the cylinder, and the gnats were blown into a porous cloth sack at-

tached below it. Another trap, the double-action type (Fig. 1), in which one light was placed above the motor and one below, was sometimes used. The gnats at-

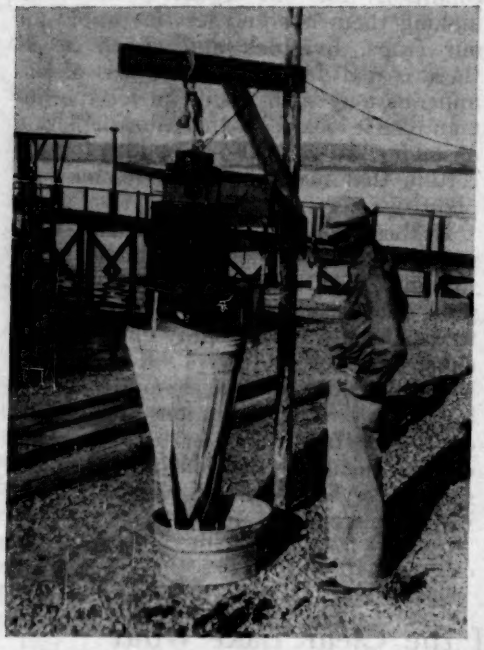

FIG. 1.—A double-action trap for the Clear Lake gnat, with a 12-inch fan and two 200-watt filament lamps.

tracted to the upper lamp were captured by suction, whereas those going to the lower light were blown into the bag. Tests with fluorescent lamps required a special type of trap to accommodate the long tubes (Fig. 2). For comparative purposes motors and fan blades were of the same size as those used in the filament-lamp traps. The wattage, lumen rating (units of light), and other pertinent data relative to the lamps and fixtures used were secured from printed information released by the company manufacturing this equipment.

EFFECT OF INTENSITY OF LIGHT.—The effectiveness of filament lamps of different intensities was studied by means of traps fitted with 10-inch electric fans. Three traps were operated 25 feet apart in a line parallel to the shore. Every third evening the traps were moved one position forward in a clockwise direction, so that each trap occupied two other positions before the rotation was repeated. A study on location efficiency was made by operating the traps with lamps of equal intensity for eight nights before the test. The average catch showed that the west location was 3.5 per cent better than the east location, but this small difference is not taken into consideration in summarizing the results of the test.

FIG. 2.—A fluorescent-type trap for the Clear Lake gnat, with a 12-inch fan and two 40-watt daylight lamps.

The data in table 1 show that the amount of gnats caught per unit of light decreased as the intensity of light increased. The larger lamps, having more

Table 1.—Comparison of amount of gnats caught with Type C filament lamps of different intensities. Average of 18 tests.

TOTAL LIGHT		AVERAGE QUANTITY OF GNATS CAUGHT			
Power	Intensity	Per Test	Per Watt	Per Lumen	TOTAL
Watts	*Lumens*	*Grams*	*Grams*	*Grams*	*Per Cent*
100	1620	543	5.43	0.335	19.1
300	5910	978	3.26	.166	34.3
500	10050	1326	2.65	.132	46.6

Table 2.—Comparative effectiveness against gnats of a double-action trap and a single-action trap. Average of 14 tests.

Type of Trap	Lamps	Total Light		Average Quantity of Gnats Caught		
		Power	Intensity	Per Test	Per Watt	Per Lumen
	Number	*Watts*	*Lumens*	*Grams*	*Grams*	*Grams*
Double-action	2	300	5200	3157	10.52	0.606
Single-action	1	300	5950	1696	5.65	.285

units of light, attracted greater amounts of gnats. Of the total gnats caught, the 100-watt lamp took 19.1 per cent, the 300-watt 34.3 per cent, and the 500-watt 46.6 per cent. The 500-watt lamp, using 5 times the electrical energy of the 100-watt lamp, took only slightly more than 2.33 times the quantity of gnats. The 100-watt lamp was the most efficient, but the increased cost of operation of the larger lamps appears justified by the increase in catch.

The double-action trap having two 150-watt *Type C* lamps was compared with a single-action trap having one 300-watt lamp. The daily average collection of 14 tests, as given in table 2, shows that nearly twice as many insects were caught in the trap fitted with the 2 smaller lamps.

COMPARISON OF LAMPS.—Since daylight and blue fluorescent lamps radiate greater spectral intensities than filament lamps within the region of 3800 to 5000 angstrom lines, the efficiency of these two types of lights was compared. A 15-watt, 18-inch tubular daylight fluorescent lamp requiring 7 watts for the ballast was compared with a 60-watt, 18-inch tubular clear *Type C* filament lamp. The traps in which these lamps were installed were identical. The size and shape of the lamps were the same and the lumen ratings similar, but they differed in the quality of light.

The results of trapping tests given in table 3 show that the fluorescent lamp captured 2.33 times as many gnats as the filament lamp, and took over 6 times as many gnats per watt of electrical input.

Table 3.—Comparative effectiveness against gnats of a *Type C* filament lamp and a daylight fluorescent lamp. Average of 9 tests.

Type of Lamp	Total Light		Average Quantity of Gnats Caught		
	Power	Intensity	Per Test	Per Watt	Per Lumen
	Watts	*Lumens*	*Grams*	*Grams*	*Grams*
Filament	60	530	474	7.91	0.895
Daylight fluorescent	15	495	1093	49.70	2.208

Since *Type C* filament lamps of higher light intensities were not available, it was necessary to use standard filament lamps in further tests. In order to evaluate lamps of equal lumen rating, a 150-watt clear filament lamp producing 2600 lumens was compared with a unit of two 30-watt daylight fluorescent lamps producing 2460 lumens and requiring ballast consuming 15 watts. The results in table 4 show that the fluorescent lamps attracted 3.67 times as many gnats as the filament lamp. On the basis of gnats taken per watt of electricity the fluorescent lamp took 7.33 times as many as the filament lamp.

Table 4.—Comparative effectiveness against gnats of 1 filament lamp and 2 daylight fluorescent lamps of nearly equal lumen rating. Average of 10 tests.

Type of Lamp	Total Light		Average Quantity of Gnats Caught		
	Power	Intensity	Per Test	Per Watt	Per Lumen
	Watts	*Lumens*	*Grams*	*Grams*	*Grams*
Filament	150	2600	505	3.37	0.194
Daylight fluorescent	60	2460	1873	24.24	.761

In table 5 are given data on tests with large traps in which the filament lamps afr exceed the fluorescent lamps in electricity consumed and lumen rating. Filament lamps totaling 1000 watts were installed in a double-action trap and compared with a trap fitted with four 40-watt fluorescent lamps (48 inches long) requiring ballast consuming 27 watts. The quantity of gnats taken per watt of electricity with the fluorescent lamps was about 7.33 times that taken with the filament lamps.

COMPARISON OF DIFFERENT COLORS.—In table 6 are given results obtained with daylight and blue fluorescent lamps. Both lamps consume the same amount of electricity and require ballast consuming 15 watts, but the daylight has a much higher lumen rating. The percentage of total

Table 5.—Comparative effectiveness against gnats of large traps equipped with daylight fluorescent and filament lamps. Average of 18 tests.

Type of Lamp	Number of Lamps	Total Light		Average Amount of Gnats Caught		
		Power	Intensity	Per Test	Per Watt	Per Lumen
		Watts	*Lumens*	*Grams*	*Grams*	*Grams*
Filament	4	600	17400	2917	2.91	0.167
	2	400				
Daylight fluorescent	4	160	5920	3564	19.06	.602

energy emitted between 3800 to 5000 angstrom lines is 10.8 for the blue and 4.8 for the daylight in 15-watt lamps (Barnes *et al.* 1939). The two lamps took about the same quantity of gnats, but on the basis of gnats captured per lumen the blue lamp was considerably better.

Table 6.—Comparative effectiveness against gnats of 2 daylight and 2 blue fluorescent lamps. Average of 10 tests.

Type of Lamp	Total Light		Average Amount of Gnats Caught		
	Power	Intensity	Per Test	Per Watt	Per Lumen
	Watts	*Lumens*	*Grams*	*Grams*	*Grams*
Blue	60	1560	4587	61.17	2.904
Daylight	60	2460	4368	58.23	1.775

A series of tests were made in which a daylight fluorescent lamp was compared with fluorescent lamps of different colors. The data in table 7 show that the daylight lamp caught more gnats and a greater quantity of gnats per lumen than the white, pink, green, or red lamps.

SUMMARY.—The attraction of lights of various intensities and wave lengths to the Clear Lake gnat, *Chaoborus astictopus* D. and S., was studied by means of suction traps. With filament lamps the amount of gnats taken per unit of light decreased as the intensity of light increased. A 500-watt lamp took slightly more than 2.3 times the amount of gnats taken by a 100-watt lamp. A double-action trap, in which a 150-watt lamp was placed above the motor, and another below, captured nearly twice as many gnats as a single-action trap fitted with a 300-watt lamp suspended above the motor.

A daylight fluorescent lamp (15-watt) attracted 2.33 times as many gnats as a filament lamp (60-watt) and took over 6 times as many gnats per watt. Studies with larger fluorescent lamps and regular filament lamps showed that, on an equal lumen-rating basis, the fluorescent lamps captured more gnats than the filament lamps and up to 7.33 times as many per watt of electrical power.

Daylight and blue fluorescent lamps attracted about the same amount of gnats, but on the basis of gnats captured per lumen the blue lamp was considerably better. Daylight fluorescent lamps were more efficient than white, pink, green, and red fluorescent lamps.—1-5-46.

Table 7.—Comparative effectiveness against gnats of fluorescent lamps of different colors in paired tests. Average of 3 to 6 tests in each comparison.

Type of Lamp	Total Light		Average Amount of Gnats Caught		
	Power	Intensity	Per Test	Per Watt	Per Lumen
	Watts	*Lumens*	*Grams*	*Grams*	*Grams*
Daylight	15	450	2029	135.25	4.508
White	15	555	1403	93.51	2.526
Daylight	15	450	1523	101.53	3.383
Pink	15	300	872	58.13	2.906
Daylight	15	450	655	43.64	1.454
Green	15	900	606	40.42	0.674
Daylight	15	450	667	44.45	1.480
Red	15	45	2	0.13	.045

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Investigations at the Henry R. Carter Memorial Laboratory of the United States Public Health Service[1].

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The Henry R. Carter Memorial Laboratory at Savannah, Georgia is a Unit of the Office of Malaria Control in War Areas, which is engaged in the control of malaria and diseases of tropical origin. The prime obligation of MCWA has been the control of malaria in extra-cantonment military areas and related defense industries. Field operational programs have been on a large scale and at a rapid pace, and the Carter Memorial Laboratory is the technical development unit for supplying information on procedures, materials, formulae, and equipment for immediate practical field use.

Work at the Laboratory is divided into nine technical Units. We shall name each of these and then briefly describe the work, purpose, and significance of each. They are as follows:

(1) Anopheline Residual Sprays
(2) Anopheline Larvicides
(3) Insect Premise Sanitation
(4) Equipment Development
(5) Effects of DDT Anopheline Larviciding on Wildlife
(6) Typhus Control Investigations
(7) Anopheline Host Preference Studies
(8) Chemical Investigations
(9) Insectary

Anopheline Residual Sprays.—The work on anopheline residual sprays has been mainly an investigation of efficiency, formulae, equipment, and methods for the large scale application of DDT. This project is divided into both field and laboratory sections. In the field several hundred houses have been experimentally treated with various DDT formulae and studies made on residual effectiveness and operational techniques. An entire village was the subject of experimental area treatment against *Anopheles albimanus* in Puerto Rico. Laboratory work consists of performing more precise tests on DDT, or other agents in regard to toxicity, in different formulae, on different surfaces, and at different exposure periods. Investigations have resulted in recommendations that were adopted for the operations of the Extended Malaria Control Program, which treated some 300,000 homes during the past season. The formula recommended and used consisted of 35 per cent DDT concentrate, containing 4 per cent emulsifier (*Triton X-100*)[2] diluted with water to 5 per cent DDT. Due to shortages of material this recommended formula was further diluted to 2.5 per cent for this season's operation. This was applied at the rate of 4 c.c. of spray per sq. ft. of surface area and was applied by both hand and power equipment. Present studies are under way in this project to determine relative effectiveness and duration of DDT applied to the various types of surfaces encountered in practical spraying, to determine factors affecting residual deterioration, and to determine natural anopheline mortality in occupied treated houses under operational conditions. Laboratory investigations are also being initiated to supplement field studies on the effects of DDT residual sprays on houseflies and blowflies as well as mosquitoes.

Anopheline Larvicides.—This project is also divided into field and laboratory sections. The field unit works on formulae, dosage, and method of application of the larvicides under investigation, while the laboratory conducts more critical tests on toxicity, physical characteristics, and deterioration of the larvicide. Most of the work to date has been with DDT. A formula and technique for the hand application of a DDT spray at the total rate of 1 gallon per acre will soon be recommended. The laboratory work has shown that the lack of residual in DDT larviciding is to a large extent due to inactivation of this chemical by the bottom mud complex in larval environments.

Due to the fact that DDT is not as spectacular a larvicide as it is a residual spray present work considers investigations of compounds related to DDT, or other indicated materials.

Insect Premise Sanitation.—Insect

[1] From Malaria Control in War Areas (Henry R. Carter Memorial Laboratory), States Relations Division.

[2] An aralkyl-polyether-alcohol supplied by the Rohm & Haas Co., Philadelphia, Pennsylvania.

Premise Sanitation in its broadest form covers the control of insects in the home that may be involved in the transmission of disease, in the contamination of food, or that are pests affecting physical or mental comfort. The work to date has been largely on the use of DDT in the control of houseflies. Some consideration has been given to blowfly control and incidental information has been secured on such insects of sanitary importance as the roach and the bedbug. Housefly control investigations have been carried on by the treatment and subsequent study of homes, grocery stores, hospitals, restaurants, pasteurizing plants, dairies, abattoirs, fish houses, and other food producing and handling establishments. Some work has been done on the use of DDT as a housefly larvicide. In many instances adequate residual spraying has been found to give a high degree of control without the necessity for auxiliary larviciding. DDT applied at the rate of 200 mgs. per sq. ft. has given phenomenal results against adult flies, where due consideration was given to the habits of the insect in choice of resting places. New techniques for determining housefly populations have been developed and these will shortly be published. The formulae procedures and equipment worked out have now been field tested in operational programs.

EQUIPMENT DEVELOPMENT.—Equipment adaptable to the diverse types of insecticides dispersal has not kept pace with needs. The advent of DDT showed that existing equipment was in many instances unsatisfactory for the quantity and type of dispersal desired. The equipment unit at the laboratory has as its function the testing for adaptability of available commercial equipment, of altering this equipment to meet operational demands, and also the design and fabrication of entirely new equipment if indicated. DDT mixing equipment was constructed which is capable of preparing in 15 to 20 minutes sufficient DDT concentrate for 650 gallons of spray. Such mixers are now in general use in the states, on the extended malaria control programs. Nozzles were tested and types selected for the proper application of residual sprays where rate of discharge, particle size, and angle of spray are important factors. Aerosol-generating equipment has been devised and tested, and extensive cooperation has been maintained in the testing of equipment submitted by the Chemical Warfare Service and the Corps of Engineers of the U. S. Army. The equipment unit serves all other projects in the design and fabrication of special experimental items when needed. On this work are three graduate mechanical engineers with assistant mechanics, and machinists.

EFFECTS OF LARVICIDING ON WILDLIFE.—The Public Health Service in its malaria control efforts must necessarily choose the materials and methods that are most effective, and yet consistent with wildlife conservation. Our tests have demonstrated DDT to be a good larvicide but the Service feels that its widespread use is feasible only if something is known regarding its effect on economic forms of life in the environments treated. Determination of this is a necessity, therefore, in order that the Service may safely employ DDT in its larviciding operations. During the past season we have conducted a thorough study on the effects of DDT larviciding on fish and associated aquatic organisms. Recently a cooperative working arrangement with the U. S. Fish and Wildlife Service was made, and the work expanded to include the effects of routine larviciding on the entire flora and fauna of the areas treated. The work is being done on the Savannah Wildlife Refuge and planes equipped for spraying, dusting, and aerosol generation have been obtained. A chemical engineer has been assigned to the study of distribution, particle size, and meteorological influence on application. The equipment unit works on alterations or development of dispersing equipment, and the results are being studied by specialists in wildlife conservation, and entomology. The program as outlined contemplates a quantitative analysis of changes that may occur, and it is felt that the data to be obtained should properly classify DDT larviciding in its relation to wildlife.

TYPHUS CONTROL INVESTIGATIONS.—The Office of Malaria Control in War Areas is conducting an operational murine typhus control program covering the higher endemic areas in some 13 states. DDT dusting is a large part of this work since investigations have shown that when properly applied, DDT dust will reduce the population of *Xenopsylla cheopis* of rats more than 95 per cent shortly after

treatment and even after 5 months the average reduction may be as much as 75 per cent. Work at the laboratory involves the experimental dusting of numerous private and business establishments in the city of Savannah. Such dusting is preceded by a flea index determination and post treatment indices have been obtained up to 5 months subsequent to treatment. In conjunction with the equipment unit, simplified dusting equipment has been devised that is now in use by typhus control operations. Investigational work has recently been initiated on rodenticides, involving both the use of 1080 and ANTU. Combinations of DDT with rodenticides to rid premises of both parasites and hosts are being investigated with some degree of encouragement. A laboratory is now being set up for more detailed parasite-host relationship studies that might be of practical significance in murine typhus control.

HOST PREFERENCE STUDIES.—The practical importance of a potential malaria vector depends upon its feeding habits. Capable vectors that do not utilize man as a host would be of no significance. We have in this country capable vectors of whose feeding habits we know practically nothing. Even in the case of *Anopheles quadrimaculatus* only meager data in regard to its feeding habits are available. The laboratory receives anopheline mosquitoes of all species available from some 25 states where MCWA Programs are in operation. Engorged specimens submitted are crushed on filter paper at the time of collection. A saline extract of the blood is prepared at the laboratory and tested by the precipitin technique against human, avian, bovine, equine, and swine antisera which is prepared at the laboratory. Results to date show that between 85 and 9 per cent of satisfactory specimens received, react to one of these antisera. The hosts of the 10 or 15 per cent of non-reactors are probably widely scattered through much of the animal kingdom. At present over 150,000 specimens have been tested, but it is felt that the importance of this work justifies additional data before the results are prepared for publication.

CHEMICAL INVESTIGATIONS.—Chemical investigations have up to the present been confined chiefly to studies connected with DDT. This project acts to a great extent as a service unit for the various other investigational projects, giving them answers to problems of a chemical nature, and conducting chemical tests pertinent to their work. Studies outlined for this unit include the cause of DDT residual deterioration and development of techniques for further refined analytical methods in the determination of minute quantities of DDT from various types of substra.

INSECTARY.—The insectary produces large quantities of specimens for use by the various investigational projects. *Anopheles quadrimaculatus* is the principal insect reared, but colonies of *Aëdes aegypti* are maintained and culture of houseflies and blowflies are being added. Orders are placed with the insectary daily for a certain number stage, and species of insect. These are kept in the proper portable cages and delivered when needed.

PERSONNEL.—The work described is conducted by a professional staff with a broad heterogeneity in training and experience and this we consider an important asset. Of the 28 professional scientists, 20 of whom are commissioned officers, there are 8 entomologists, 7 engineers, 2 chemists, 1 veterinarian, and 10 zoologists and biologists. The engineers are sanitary, chemical, mechanical and civil, while among the biologists are wildlife specialists, parasitologists, protozoologists, and medical technicians. The professional staff is augmented by adequate sub-professional and auxiliary personnel.

The control of insects of medical and sanitary importance has expanded into a broad field with diverse professional demands, and the coordination of professional talents is an essential step toward mutual understanding and increased accomplishments.—12-21-45.

Insect Pollinators of Alfalfa in California

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Alfalfa is one of California's most important agricultural crops. Since seed production is basic to the growing of alfalfa, much concern has been felt in recent years over a rather general decline in yields per acre in the most important seed-producing areas. Although the reasons for this decline are undoubtedly complex, most of the difficulty has centered around failure to set seed. Recent investigations (Armstrong & White 1935; Tysdal 1940; Knowles 1943) would seem to substantiate the earlier conclusions of Brand & Westgate (1909), Piper *et al*, (1914), and other workers, that alfalfa seed setting depends largely on tripping and cross-pollinating insects, although it has been shown that a high degree of natural self-tripping and self fertility exists in certain autogamous selections and their derived selfed lines and F_1 hybrids (Kirk 1933).

A great variety of insects are associated with the flowers of alfalfa which might conceivably be involved in their pollination. The most numerous of these are bees, flies, thrips, and butterflies. However, although alfalfa flowers depend upon insects for pollination, they are not adapted for obtaining pollination in the most effective manner. Müller (1873) and others have pointed out that insects may readily obtain nectar without tripping the flower by simply inserting the proboscis at one side of the keel, and that the flowers continue to secrete nectar even after tripping, thus remaining attractive beyond the period when they can receive the maximum benefit from insect visitation. Effective pollinators, then, must either regularly and deliberately trip the flowers in search of pollen, or must frequently, but accidentally, trip them while seeking nectar or while feeding.

Among the flower visiting insects other than bees, butterflies have probably received more attention as potential pollinators than any otner group. This is particularly true of the alfalfa butterfly, *Colias eurytheme* (Bdv.), which often visits blooming seed fields in large numbers. Most investigators report the failure of this species to trip alfalfa, although Wildermuth (1911) saw a few individuals trip flowers during one season. In any event, it is generally agreed that neither this nor other species of butterflies are important agents in alfalfa pollination. With regard to thrips, Piper and his coworkers conclude from studies conducted in various parts of the country, that they, likewise, are unimportant factors. These authors do mention, however, that certain blister beetles, notably *Macrobasis unicolor* Kirby, which are injurious to the flowers, incidentally trip many while feeding, and Tysdal *et al.* (1942) record the leather-winged beetle, *Chauliognathus*, as a possible important pollinator. Experiments by Piper and colleagues designed to determine the effectiveness of moths and various night flying insects led them to the conclusion that such insects played at most a minor role in tripping alfalfa flowers.

As early as 1873, Urban, after reviewing previous work, concluded that bees were the primary agents in alfalfa pollination. Attention first centered on the honeybee, and most investigators now agree that this species is an undependable pollinator. Henslow (1867) watched honeybees collecting alfalfa nectar, but in no instance did he see them trip flowers. Burkhill (1894), in a series of observations, did find honeybees tripping flowers on two occasions. Westgate (1909) reports that out of more than 500 visits of honeybees to alfalfa flowers, only one resulted in tripping. Piper *et al.* (1914) record honeybees tripping 0.31 and 1.58 per cent of the flowers visited at Pullman, Washington, in successive years, and 4.76 per cent at Chinook, Montana. Sladen (1918) found honeybees plentiful in fields in Alberta and British Columbia, but they visited the flowers without tripping them. Tysdal (1940), from counts made in Ohio, Nebraska, and Wyoming, concluded that ". . . the honey bee was not an effective tripper of alfalfa flowers. Out of 6653 flowers visited by honeybees, a total of 76 or 1.1 per cent were tripped. . . . During the same period 798 flowers were

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Table 1.—Alfalfa pollinators previously reported in North America.[1]

SPECIES	AREA				
	Washington & Brit. Col.	Alberta & Sask.	Rky. Mtn. States	Nebraska	Eastern U. S.
ANDRENIDAE					
Andrena sp.	x (P)[2]			x (T)	x (P)
HALICTIDAE					
Nomia melanderi Cockerell			x (T)		
Nomia sp.			x (T)	x (T)	
MEGACHILIDAE					
Megachile densitarsus Sladen		x (S)			
Megachile perihirta Cockerell	x (S)	x (S)			
Megachile melanophea var. *calogaster* Cockerell	x (S)	x (S)			
Megachile vidua Smith	x (S)	x (S, K)			
Megachile manifesta Cresson	x (S)	x (S)			
Megachile montivaga Cresson		x (K)			
Megachile latimana Say	x (P)	x (K)	x (P)		
Megachile pugnata Say		x (K)			
Megachile sp.		x (K)	x (T)	x (T)	x (T)
APIDAE					
Melissodes sp.				x (T)	
Bombus sp.				x (T)	x (T)
Bombus auricomus Rob.			x (T)		
Bombus separatus Cresson			x (T)		
Bombus bifarius Cresson			x (T)		
Bombus borealis Kirby			x (T)		

[1] Exclusive of the honeybee.
[2] Symbols: S = Sladen (1918).
T = Tysdal (1940) or Tysdal *et al* (1942).
K = Knowles (1943).
P = Piper *et al* (1914).

visited by leaf-cutter bees (*Megachile*) and 674 or 84 per cent were tripped."

Piper *et al* (1914), Aicher (1917) and Sladen (1918ab) were among the first to emphasize the importance of wild bees, especially *Megachile* (leaf-cutter bees) and *Bombus* (bumblebees) in the pollination of alfalfa in various parts of the United States and Canada. Piper and his colleagues in two different areas found *Megachile latimana* Say tripping 90.38 and 93.33 per cent of the flowers visited, Three individuals were timed tripping flowers at an average rate of 9.2 per minute or 552 flowers per hour. At Havre, Montana they reported bumblebees tripping 29.47 per cent of the flowers visited. In Alberta, Sladen found *Megachile densitarsus* Sladen the most abundant leaf-cutting bee in alfalfa seed fields, and it was observed tripping flowers at the rate of 17 per minute. He noted that bumblebees, although fairly abundant, worked more slowly and often failed to trip flowers. Tysdal (1940) also reported bumblebees variable in their effectiveness, tripping from 38 to 80 per cent of the flowers visited. He concluded from his studies that bumblebees are the most important pollinators in the eastern states, leaf-cutter bees in the middle western states, and alkali bees (*Nomia* spp.) in the west. In the last two areas, species of *Megachile* and *Nomia* tripped more than four times as many flowers as all other insects combined. In Saskatchewan, Knowles (1943), also found leaf-cutter bees to be important. *M. vidua* Smith was the most abundant species, with *M. montivaga* Cresson, *M. latimana* Say, *M. pugnata* Say and certain other species also involved. In Europe, the importance of bees, in relation to alfalfa has also been recognized. Among the wild bees, Helmhold (1929) mentions *Macropis labiata* Fab., *Melitta lepurina* Panzer, and *Anthophora bimaculata* Panzer. Apparently no previous survey has been made of alfalfa pollinators in California.

METHODS.—During the course of the present study, direct observation was relied upon to determine which of the pollen-collecting bees in alfalfa fields were tripping and cross-pollinating, as well as other facts relative to their habits and

Table 2.—Alfalfa pollinators in California.

Species	Area				
	Blythe	Hemet	Tracy-Patterson	Ryer Island	Misc. N. Calif.
COLLETIDAE					
Hylaeus sp.	—	—	x	—	—
HALICTIDAE					
Agapostemon cockerelli Cwfd.	—	x	x	x	x
Agapostemon melliventris Cress	x	—	—	—	—
Halictus farinosus Say	—	x	x	—	—
Halictus ligatus Say	—	x	x	x	—
Halictus tripartitus Ckll.	—	—	x	x	x
Lasioglossum sp.	x	—	—	—	—
Lasioglossum glabriventris Cwfd.	—	x	—	—	—
Lasioglossum sp.	—	x	x	—	—
Lasioglossum incompletus Cwfd.	—	—	x	x	x
Lasioglossum diversopunctatus Ellis	—	—	x	x	x
Nomia peninsularis Ckll.	x	—	—	—	—
Nomia nevadensis Cresson	x	x	—	—	—
Nomia melanderi Ckll.	—	x	x	—	—
MEGACHILIDAE					
Anthidium edwardsii Cresson	—	x	x	x	x
Diceratosmia subfasciata subsp. *punctata* Michener	x	—	—	—	—
Megachile brevis Say	x	x	x	x	x
Megachile onobrychidis Ckll.	—	x	x	x	x
Megachile gentilis Cresson	x	x	—	—	—
Megachile sidalceae Ckll.	x	—	—	—	—
Megachile coquilletti Ckll.	—	x	—	—	—
Megachile perihirta Ckll.	—	—	x	x	x
APIDAE					
Exomalopsis albicans Prov.	—	x	—	—	—
Melissodes timberlakei Ckll.	x	x	x	x	x
Melissodes obliqua Say	x	x	—	x	—
Melissodes agilis Cresson	—	—	x	—	—
Melissodes sp.	—	x	—	—	—
Melissodes lupina Cresson	—	—	x	—	x
Melissodes stearnsi Ckll.	—	—	x	—	—
Anthophora californica subsp. *albomarginata* Timberlake	x	—	—	—	—
Anthophora urbana Cresson	—	x	x	x	x
Hemisia pallida (Fox)	x	—	—	—	—
Xylocopa varipuncta Patton	x	x	—	—	—
Bombus californicus Smith	—	x	x	x	x
Bombus crotchii Cresson	—	x	x	—	—
Bombus sonorus Say	—	x	x	x	—
Bombus nevadensis Cresson	—	—	—	—	x
Bombus morissoni Cresson	—	—	—	—	x
Bombus hunti Greene	—	—	—	—	x
Apis mellifera Linn.	x	x	x	x	x

behavior. The general survey, however, was based upon samples taken in counts from 25 broad sweeps with a net across the blossoms while the collector moved rapidly through the field taking about two strides between each sweep. From eight to 20 such 25-sweep counts were taken in each field depending upon its size. The advantages of this method over various others which have been previously used are (1) that the results can be readily duplicated by other observers, (2) the bees may be anaesthetized in the net before counting making more accurate identifications possible (questionable specimens may be retained for further study), (3) counts are not handicapped under unfavorable conditions for observation, as when a strong wind is blowing, (4) counts reveal the presence of species not otherwise noted by the observer, either because of their rapid reaction to his approach or

because they are not conspicuous, (5) it is possible to accurately determine whether or not each captured individual was actually collecting pollen (if necessary pollen-collectors may be retained for pollen analysis). The main disadvantage of the method is that as a result of different flight habits and behavior patterns, it presumably collects a larger proportion of honeybees than wild bees, but in the present study this would seem to be compensated for by the fact that it provided a uniform method of comparing one field with another.

AREAS SURVEYED—Four California areas were investigated during the 1945 season. The first of these was the Palo Verde Valley in the vicinity of Blythe, on the Colorado River in eastern Riverside County. Here counts were taken in thirteen seed fields and casual observations made in several others. The surrounding region is a desert and the area is completely isolated from the alfalfa growing regions of southern California.

The second area was in the vicinity of Hemet, in western Riverside County, near the northwest base of the San Jacinto Mountains. This region is much more intensely cultivated but is surrounded by dry, rolling, uncultivated hills.

The third area lies between Tracy and Patterson in San Joaquin and Stanislaus Counties near the northwest end of the San Joaquin Valley, in one of the richest agricultural areas of the state.

The fourth area was Ryer Island, in the delta region of the Sacramento River. This locality differs markedly from the other three in the presence of a high water table, making irrigation of alfalfa unnecessary.

SPECIES COMPOSITION OF POPULATIONS.—As would be anticipated, the species composition of the populations of pollinating bees varied with the areas studied (Tables 2, 3 and 4). The greatest difference was evident in the Blythe area, where several species occurred which did not appear elsewhere, notably *Agapostemon melliventris*, *Nomia peninsularis*, *Diceratosmia subfasciata punctata*, *Megachile sidalceae*, *Anthophora californica albomarginata*, and *Hemisia pallida*. All of these are largely Lower Sonoran species which have moved over to alfalfa from various desert and semi-desert plants. The remaining three areas, although separated in the extreme by more than four hundred miles are remarkably similar in their species composition as indicated by the present season's study.

It is interesting to note that up to the present time, only two species other than the honeybee were found in alfalfa fields in all four areas, namely *Megachile brevis* and *Melissodes timberlakei*, which when abundant, appear to be two of the most effective trippers and cross-pollinators encountered in the study.

The following species were found pollinating alfalfa in the areas surveyed in 1945.

YELLOW-FACED BEES.[1]—On September

[1] Colletidae: Hylaeinae.

Table 3.—Occurrence of pollinating bees in alfalfa seed field in the Palo Verde Valley, California.

SPECIES	FIELDS												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Agapostemon melliventris		x		x							x		x
Lasioglossum sp.							x	x		x			x
Nomia peninsularis	x	x	x	x	x	x	x	x	x	x	x	x	x
Nomia nevadensis				x	x	x	x	x	x	x	x	x	x
Diceratosmia subfasciata punctata											x	x	x
Megachile gentilis					x			x	x	x			x
Megachile brevis													x
Megachile sidalceae													x
Melissodes timberlakei				x	x	x		x					x
Melissodes obliqua							x						
Anthophora californica albomarginata	x	x		x	x	x	x	x	x		x	x	x
Xylocopa varipuncta						x			x	x	x	x	x
Apis mellifera	x	x	x	x	x	x	x	x	x	x	x	x	x

6, large numbers of yellow-faced bees (*Hylaeus* sp.) suddenly appeared in one field in the vicinity of Tracy, although none had been taken previously and none were found subsequently in this or any other field under observation. On this date the bees were observed cross-pollinating flowers which had been tripped by other bees, primarily *Megachile* spp. and *Melissodes* spp. The reasons for the sudden appearance and disappearance of this species are not evident but the probabilities are that it is not an important factor in alfalfa pollination.

SWEAT BEES[1].—Metallic Sweat Bees.—*Agapostemon cockerelli* Crawford occurs in western North America from British Columbia to Mexico. It is the commonest member of the genus in California and was found in alfalfa fields in all of the areas under study except Blythe. It collects pollen from a wide variety of plants, but when working alfalfa it is an efficient pollinator. In the Ryer Island fields, large numbers of males appeared on September 12 and continued abundant through the 19th, when counts were terminated, although females had been taken but sparingly during the rest of the season. This suggests that a large population of *A. cockerelli* was nesting in the area but that relatively few were collecting pollen from alfalfa. This species nests very deeply in hard soil, far below the level of cultivation The males appear late in the fall and mate with the females which then hibernate like various species of *Halictus* and provision their cells and rear their brood during the following season.

Table 4.—Occurrence of pollinating bees in alfalfa seed fields in the Hemet area, California.

SPECIES	FIELDS						
	1	2	3	4	5	6	7
Agapostemon cockerelli	x	x		x			x
Halictus farinosus		x					
Halictus ligatus			x	x			
Lasioglossum glabriventris	x			x			x
Lasioglossum sp.			x				
Nomia melanderi	x	x		x			x
Anthidium edwardsii	x	x	x				x
Megachile brevis	x			x			
Megachile onobrychidis	x						
Megachile coquilletti		x	x				
Megachile gentilis							x
Exomalopsis albicans							x
Melissodes obliquus							x
Melissodes timberlakei	x	x	x	x		x	x
Melissodes n. sp.		x					
Anthophora urbana	x						x
Bombus crotchii	x	x	x		x		x
Bombus sonorus							x
Bombus californicus	x						x
Apis mellifera	x	x	x	x	x	x	x

Agapostemon melliventris Cresson was found pollinating alfalfa only in the Blythe area, although it was present in significant numbers in but four of thirteen fields. It occurs in southwestern United States and northern Mexico (Sandhouse, 1936), and like other species of the genus, will apparently collect pollen from a wide variety of flowers. In the Blythe area, while alfalfa was in bloom, *A. melliventris* was observed collecting pollen from most of the other pollen plants which were blossoming at the same time. Even among the legumes, *Melilotus* and certain other species appeared to be preferred to alfalfa. Nevertheless, when collecting pollen from alfalfa it is slightly more efficient than the honeybee. On a cloudy day at 9 a.m. it was timed tripping flowers at the rate of 4 per minute as against 3.5 for the honeybee, and on a clear hot day at 8:30 a.m. it averaged 9.5 flowers per minute as against 8 per minute for the honeybee.

Table 5.—Occurrence of pollinating bees in alfalfa seed fields in the Tracy-Patterson area, California.

SPECIES	FIELDS					
	1	2	3	4	5	6
Hylaeus sp.	x					
Agapostemon cockerelli				x		
Halictus tripartitus	x	x	x		x	x
Lasioglossum n. sp.	x					
Lasioglossum incompletum	x	x	x	x	x	x
Nomia melanderi					x	
Anthidium edwardsii	x	x				x
Megachile brevis	x	x			x	x
Megachile onobrychidis	x	x			x	x
Melissodes timberlakei	x	x	x	x	x	x
Melissodes agilis	x					
Melissodes lupina						x
Melissodes stearnsi			x			x
Bombus crotchi			x			
Apis mellifera	x	x	x	x	x	x

Like *A. cockerelli*, this species nests deep in the soil, below the level of cultivation. The males appeared earlier in the year than some other species of *Agapostemon*, presumably because under the desert conditions that prevail in the Blythe area, the season is considerably advanced.

TRUE SWEAT BEES[2].—The common and widely distributed *Halictus farinosus* Say was found occasionally in alfalfa fields in both the Hemet and Tracy-Patterson areas. Like the honeybee, it will collect from most pollen-producing plants and prefers a great many other common pollen

[1] Halictidae: Halictinae.

[2] *Halictus* and *Lasioglossum*.

sources to alfalfa. Although it effectively trips and pollinates alfalfa when working it, the probabilities are that it will prove to be an important pollinator only under exceptional circumstances.

The pollen collecting habits of *Halictus ligatus* Say are similar to those of *H. farinosus*, and it was encountered under much the same circumstances. Although slightly more abundant in alfalfa fields, it is probably equally undependable as a pollinator.

Halictus tripartitus Cockerell is a small bee and is very common in alfalfa fields in the San Joaquin and Sacramento Valleys. In the Tracy-Patterson area it was present in every field investigated. It is an effective cross-pollinator of alfalfa but confines its visits largely to flowers tripped by other bees. It was actually observed tripping flowers on a few occasions but it was not clear whether this was the result of deliberate action on the part of the bee or of accident. Males were rarely encountered during the season of alfalfa bloom.

This species nests semi-gregariously, in flat areas, below the level of cultivation.

Lasioglossum incompletum (Crawford) is even smaller than the preceding. It was found equally abundant in the San Joaquin and Sacramento Valleys, where it cross-polinated tripped flowers. Its nesting habits are similar to those of *Halictus tripartitus*, although males were abundant throughout most of the alfalfa blooming season.

Lasioglossum glabriventris (Crawford) was found in fields in the Hemet area, behaving much as *L. incompletum*. Two similar but undetermined and presumably new species were taken in the Blythe and Hemet areas, respectively.

ALKALI BEES[1].—*Nomia peninsularis* Cockerell is the commonest and most important pollinator among the wild bees in the Blythe area, and was present in every field surveyed. It is a rapid worker and effective cross-pollinator. On June 8, at 9:30 a.m., it was timed tripping flowers at the average rate of 22 per minute. This was a clear, warm day. On June 22, at 4:30 p.m., with the sky partially overcast, it was tripping flowers at the average rate of 12.6 per minute. The nesting habits of *N. peninsularis* were not fully investigated. However, it was found nesting semi-gregariously along dirt roads and among roadside weeds, in a sandy, alkali soil. The burrows were about 5 mm. in diameter and averaged about 8 inches apart in the denser areas. One incomplete burrow was excavated and the first cells were encountered at a depth of about two and one-half inches. In view of the fact that most species of *Nomia* tend to excavate much deeper burrows and to place their first cells at a lower level, it is possible that this burrow was not typical.

[1]Halictidae: Nomiinae: *Nomia*

Table 6.—Occurrence of pollinating bees in alfalfa seed fields on Ryer Island, California.

SPECIES	FIELDS	
	1	2
Agapostemon cockerelli	x	x
Halictus tripartitus	x	x
Halictus ligatus	x	
Lasioglossum incompletum	x	x
Anthidium edwardsii	x	x
Megachile perihirta	x	x
Megachile brevis	x	x
Megachile onobrychidis	x	x
Melissodes timberlakei	x	x
Melissodes obliqua	x	x
Anthophora urbana	x	x
Bombus sonorus	x	
Bombus californicus	x	x
Apis mellifera	x	x

Nomia melanderi Cockerell is very closely related to the preceding and appears to have similar habits. It is much more widely distributed, however, occurring from the Pacific northwest to southern California and the Rocky Mountain states, where it has been recorded by Tysdal (1940) as an important alfalfa pollinator. In California, it was found abundantly only in the Hemet area and was encountered in a single field in the Tracy-Patterson area. It is probable that further surveys will reveal it to be an important pollinator in various other parts of the state. *N. melanderi* also nests in flat, alkali soil. Its cell series occur at different levels, usually from six to twelve inches.

Nomia nevadensis Cresson is primarily a pollinator of Compositae, and in the Blythe area is extremely abundant on arrowweed (*Pluchea sericea*), which is common along the levees, roadsides, and in uncultivated areas. However, due to the large populations which occur in the area, it was present in effective numbers in ten of the twelve Blythe fields. In the

Hemet area, the species was fairly common but was not found collecting pollen in any of the fields under observation.

At Blythe, an opportunity arose to observe the nesting habits of this species. It was discovered nesting gregariously in tremendous numbers in flat areas of sandy, alkali soil adjacent to, or along levees. The entrance ways were protected by a curved turret suggestive of those constructed by certain anthophorids. The burrow itself extends down perpendicularly for 9 or ten inches, then turns abruptly in a horizontal plane. Here it may branch and continue with a series of cells placed below the tunnel. After three or four inches the tunnel then turns abruptly downward again for another five or six inches, then levels off with a new series of cells. This may be repeated to a depth of 18 to 24 inches, although cell series are rarely found below 15 or 16 inches. Below the burrows, the cell arrangement is usually not always regular or in the same plane.

Nomia nevadensis is an active bee and efficient pollen collector. On June 24, females were flying over a nesting site at 7 a.m. and several began bringing in loads of pollen at 7:50 a.m. On several occasions they were observed still collecting pollen industriously at 6–6:30 p.m.

COTTON BEES.[1]—*Anthidium edwardsii* Cresson was found collecting pollen from alfalfa in all of the areas surveyed except Blythe. It is a rapid worker, tripping and pollinating in much the same way as *Megachile*. In the Hemet area it was present in effective numbers in four out of seven fields, in the Tracy-Patterson area in three out of six fields, and in both fields at Ryer Island. It was most numerous in July and August and by September had begun to disappear.

A. edwardsii is a ground nesting form, utilizing burrows of *Sphex* and other ground nesting wasps in roadways, and other bare areas. Its nests are usually from four to five inches deep, well within the level of cultivation.

OSMIINE BEES.—*Diceratosmia sulfasciata punctata* Michener was found to be an effective pollinator in three fields in the Blythe area. It was observed tripping flowers at the rate of 9.5 per minute at 8:30 a.m. on a clear warm day. The species nests in old burrows of wood-boring beetles, especially those of bostrichids, cerambycids, and buprestids. The three fields concerned were in outlying areas adjacent to thickets of willow, mesquite, and other trees containing suitable burrows. Here the populations of *Diceratosmia* were large and they represented a high percentage of the effective pollinators in the fields.

LEAF-CUTTING BEES.[1]—*Megachile perihirta* Cockerell is widely distributed in western North America and was the largest species of *Megachile* (12-13 mm.) found in alfalfa fields during the present study. On Ryer Island, where it was very abundant in the two fields under observation, it was observed tripping alfalfa flowers at an average rate of 23.4 per minute at 9:30 A.M. Here it was nesting both in the ground and in stacked bales of hay and flying a quarter of a mile to the farmhouse garden for leaves of rose bushes and other shrubs for lining its cells.

Sladen (1918a–b) found this species tripping alfalfa flowers in Alberta and British Columbia. It was also observed nesting gregariously in a nearly new, bare, gravel railway embankment in Ontario and in a nearly new gravel road leading to a dwelling in British Columbia. He stated "there is, therefore, some hope that *perihirta* might be encouraged to breed in the vicinity of alfalfa fields by spreading gravel and making it firm by rolling." However, observations by the writer as well as those of Hicks (1926, 1936), indicate that this species also nests in sandy and clay soils devoid of gravel. In Colorado, Hicks observed this species collecting pollen at 8:30 A.M. He also noted that the duration of the pollen collecting trips was from 20 to 25 minutes and that the female spent from 2–10 minutes in the nest between trips. Apparently about a day is required to construct and store pollen for a single cell.

Two closely related species, *Megachile densitarsus* Sladen (=*M. diligens* Sladen, not Smith) and *M. latimanus* Say are also important pollinators of alfalfa. The former occurs in the Pacific Northwest and through the Rocky Mountain region to New Mexico, the latter from the Rocky Mountains eastward (Mitchell 1936). All of these species appear to collect pollen from both legumes and composites. *M. perihirta* has been found taking pollen from *Trifolium* and *Meliotus*. Mitchell (1936) lists a number of other flowers

[1] Megachilidae.

records but does not designate those from which the bees were taking pollen.

Megachile brevis Say is one of the commonest and most widely distributed species of Megachile in North America, occurring throughout the United States and southern Canada. It flies throughout the season when alfalfa is in bloom, is an effective pollinator of that plant, but shares its activities with other Leguminosae (esp. *Lotus*, *Melilotus*, *Trifolium*, and *Lupinus*), many Compositae, and certain other plants. In spite of this fact, it was found in significant numbers in some of the fields in all areas studied, and was especially effective in the San Joaquin and Sacramento Valleys. It is a rapid worker and at 9:30 A.M. on Ryer Island, was timed tripping flowers at an average rate of 20.2 per minute. On one occasion it was still working actively at 6:15 P.M. The species normally nests in hollow stems of annual and perennial plants, or in burrows of wood-boring insects. In addition, Rau & Rau (1916) found the species nesting in a railroad tie, and Hicks (1926) and Rau (1934) have recorded the species nesting under or between rocks. Since *M. brevis* is part of a complex of species or subspecies, it is not certain that all of these observations pertain to the same form.

Megachile onobrychidis Cockerell is a western form very similar to *M. brevis* and is treated by Mitchell (1935) as a variety of that species. In the fields surveyed it was present in about equal numbers with *M. brevis* and as far as could be determined its habits are very similar.

Megachile coquilletti Cockerell, closely related to the two preceding, was found collecting pollen in two fields in the Hemet area. It occurs along the Pacific Coast and eastward into Idaho and Utah, but little is known of its habits. Mitchell (1935) records it from flowers of *Eriogonum* and *Cleomis*.

Megachile gentilis Cresson occurs from the Pacific Coast to Texas and Idaho. In California it was taken pollinating alfalfa only in the Blythe and Hemet areas but will probably be found elsewhere. It has a long flight period and probably collects pollen from a wide variety of plants. Mitchell (1935) lists *Lotus* and *Eriogonum* as flowers visited by this species.

Megachile sidalceae Cockerell was encountered in alfalfa fields only at Blythe. It is a desert species occurring from Texas to southern California and south into Mexico. It apparently normally collects pollen from mesquite and possibly other legumes, although it has been collected on *Sidalcea* and various Compositae.

ANTHOPHORID BEES.[1]—*Exomolapsis albicans* Provancher was observed collecting pollen from alfalfa in one field in the Hemet area. The probabilities are that it was overlapping from some other plant and will only occasionally prove of importance in alfalfa pollination.

LONGHORNED BEES.[1]—*Melissodes timberlakei* Cockerell is the commonest and most abundant species of *Melissodes* pollinating alfalfa in California. It was found in each of the areas investigated (Blythe, Hemet, Tracy, Patterson, Ryer Island) in the course of this study and was taken at Alturas, Modoc Co., and at Davis, California as well as at Yuma, Arizona, by Dr. O. C. Riddle. At Blythe it was present in significant numbers in five out of thirteen fields, at Hemet in six out of seven fields, in the Tracy-Patterson area in all six fields as well as in both fields on Ryer Island. It is a rapid and effective pollinator. On Ryer Island, at 9:30 A.M. it was observed tripping an average of 18.8 flowers per minute.

The species nests in bare ground at a depth of from three to six inches, well within the depth of cultivation. The entrance tunnel is about 6 mm. in diameter and enters perpendicularly for about three inches, then turns abruptly at right angles. The nest series consists of cells placed vertically in short extensions from the main shaft. A brief account of the nesting habits has been given by Hicks (1926).

Melissodes obliqua (Say) is the largest of the species of *Melissodes* encountered in alfalfa fields. It is widely distributed in western North America and collects pollen primarily from Compositae such as *Helianthus*, *Grindelia*, etc. However, it was found collecting alfalfa pollen in one field at Blythe, one at Hemet, and one on Ryer Island. It works very fast, is an effective pollinator, but presumably only turns to alfalfa as a pollen source when suitable Compositae are unavailable. The species nests in bare ground, the cells usually occurring at a depth of from six to ten inches. Frequently several females use the same entrance burrow. The burrow enters the ground perpendicularly,

[1] Apidae: Anthophorinae.

then turns suddenly at a right angle and opens into an antechamber, presumably to permit the passing of bees. From the antechamber, other burrows lead out to the next series containing the cells. An account of the nesting habits of this species in Colorado has been given by Custer (1928).

Melissodes stearnsi Cockerell was observed collecting pollen from alfalfa in several fields in the Tracy-Patterson area, but was present in significant numbers in only one of those under observation. No opportunity was offered for the study of its habits or the evaluation of its importance. *M. agilis* Cresson was also abundant in one of the fields in the same area. Elsewhere it was rarely encountered or represented by a few males in search of nectar. This was also true of *M. lupina* Cresson.

A sixth species, which Mr. Timberlake informs me is apparently undescribed, was taken pollinating alfalfa in a field at Hemet. Too little was observed of its habits to evaluate it at this time.

FURRED BEES.—*Anthophora californica albomarginata* Timberlake is one of the most common bees in the alfalfa fields in the Blythe area. However, it collects pollen from a wide variety of other plants, especially from tamarisk, arrowweed, and other plants growing along the levees which bisect the Palo Verde Valley. Nearly half of the individuals encountered in alfalfa fields are not collecting pollen, although a good many of these are males. When collecting alfalfa pollen, this species is a fast and effective tripper and cross-pollinator, and in several fields appear to be accomplishing a significant amount of pollination.

The species nests semi-gregariously or in solitary burrows in banks or occasionally flat ground. The cell series are at a depth of from four to eight inches.

Anthophora urbana Cresson is probably the commonest member of the genus on the Pacific Coast. It has been found in alfalfa fields in all of the areas thus far surveyed in California except Blythe. Mr. H. M. Tysdal noted it tripping flowers in a field at Klamath Falls, Oregon, on July 27. Unfortunately, the species, like the honeybee, collects pollen from a great many different species of flowers, and is to be found in numbers in alfalfa fields only when other more readily available pollen plants are absent or through blooming. When collecting pollen it trips flowers rapidly and both Dr. O. C. Riddle and the writer have independently noted it tripping flowers deliberately while collecting nectar alone.

This species is semi-gregarious and frequently nests in large "colonies" in bare flat land, roadways, banks, and cliffs. It is a strong flier and will fly a distance of a mile or two when necessary, in its search for nectar or pollen.

Hemisia pallida (Fox) was not taken in any of the surveys but was observed tripping flowers and collecting pollen in one of the fields at Blythe by Mr. Fred Platt. It is a desert species, normally visiting *Dalea*, *Cercidium*, and other leguminous trees and shrubs. Because of its size and speed it would undoubtedly prove to be a very effective pollinator of alfalfa if it should visit fields in significant numbers. However, the probabilities are that it will be only occasionally attracted to alfalfa. In any event, it would be limited to fields adjacent to desert areas.

CARPENTER BEES.[1]—The valley carpenter bee, *Xylcopa varipuncta* Patton, is a very effective pollinator of alfalfa. In a field at Blythe, California, it was observed tripping and pollinating flowers at the average rate of 23 per minute at 8:30 A.M. It not only trips flowers deliberately while collecting pollen, but, because of its weight, was frequently noted tripping flowers mechanically when alighting on or taking off of a raceme. It was present in significant numbers in six of the thirteen fields under observation at Blythe and was particularly common in the fields adjacent to the Colorado River, where an abundance of suitable dead wood was available for nesting purposes. At Hemet, California, the species was observed in several fields but was not present in significant numbers in any of those involved in the present study.

The females of the valley carpenter bee, are large (18–23 mm.), robust, black bees with brilliant violaceous or brassy reflections. The males are golden brown. The species nest in dead and often partially decayed oak, mesquite, eucalyptus, pepper and other broad-leaved trees. The burrows are from five to twelve inches long, usually follow the grain, and several

[1]Apidae: Xylocopinae.

may have a common entrance. Within the burrows a series of cells is constructed, each provisioned with pollen for a single larva, and separated from the adjacent cell by a spiral disc of wooden chips. Under favorable conditions a female provisions about one cell a day. The species is fairly common in the Southwest, especially in the valleys and foothill areas. A brief account of its habits has been given by Nininger (1916).

BUMBLEBEES.—*Bombus crotchii* Cresson proved to be the commonest bumblebee encountered in alfalfa fields this season, and was particularly abundant in the Hemet area. In one field, the population reached a peak of 18 per 100 sweeps. About one-third of these, however, were males, and among the females, only about 80 per cent were collecting pollen. Although individually bumblebees are more dependable than honeybees in alfalfa pollination, they are much less effective than most solitary bees. Outside of the Hemet area they were not abundant enough to be regarded as important pollinators, and at Hemet, the populations varied tremendously from field to field and from one part of a single field to another. Since this variation did not coincide with variations in the density of honeybees and wild bees in general, it was presumed that it may have been influenced by nearness of nesting sites, although this was not determined by actual observation.

As with the preceding species, *Bombus californicus* Smith did not appear to be a dependable alfalfa pollinator. When actively collecting pollen it trips a large number of flowers but carries its pollen in a moist ball, as do other bumblebees and honeybees, and it is thus less readily available for cross pollination. It was found in small numbers in most of the areas surveyed but was regarded as important in only a few of the fields studied. *B. sonorus* was fairly abundant in the Hemet area, and was occasionally found elsewhere, but its importance would appear to be about the same as that of *B. crotchi* and *B. californicus*.

Bombus nevadensis Cresson, *B. morrisoni* Cresson, and *B. hunti* Greene were all collected tripping alfalfa flowers in a seed field at New Pine Creek, Modoc County, on July 30, 1945, by Dr. O. C. Riddle. This suggests that in the northeastern part of the state bumblebees may play a greater role in alfalfa pollination than in the other areas thus far investigated.

THE HONEYBEE.—*Apis mellifera* L. As would be anticipated, the honeybee was present in every alfalfa seed field surveyed. However, in general the density of pollen-collecting individuals compared unfavorably with that of the solitary bees, both on an area basis and on a field basis. The effectiveness of honeybees in pollinating alfalfa is modified by many factors, the most important of which will be discussed in another report. Although the honeybee must be regarded as a potentially important alfalfa pollinator, it did not live up to its potentialities in any field surveyed in any of the areas during the four months period in 1945 when these studies were conducted. The data accumulated during the present season leads to the inescapable conclusion that the major portion of the pollination of alfalfa in the areas surveyed was accomplished by solitary bees. It is possible, however, that the areas and fields selected are not representative of conditions as they exist in the state as a whole, or that the 1945 season was not normal in this regard for the areas involved. The general accuracy of the present picture can only be determined by future studies.

MISCELLANEOUS INSECTS.—Various nectar gathering insects other than bees were also observed in the course of the present study, to determine whether or not any of them consistently tripped alfalfa flowers. Special attention was given to bombyliid and syrphid flies, vespoid and sphecoid wasps, butterflies and certain other groups of insects. No other species of insect was observed to deliberately trip an alfalfa flower in the sense that it is tripped by a bee. All of them extracted nectar through the side of the blossom, although in the Blythe area one large scoliid wasp (*Campsomerus plumipes* Cresson) frequently tripped flowers with its feet when alighting or taking off from a raceme. In view of its abundance in several fields it is probable that it may be regarded as a factor in tripping, if not in pollination.

CONCLUSIONS.—From the data obtained in surveys of alfalfa seed fields in four areas of California during the season of 1945, the following conclusions may be drawn:

(1) The only significant insect agents of alfalfa pollination appear to be bees. No other insects were observed to deliberately trip alfalfa flowers, although a scoliid wasp, *Campsomerus plumipes*, trips and cross-pollinates mechanically in the Palo Verde Valley.

(2) In each of the areas concerned in the study the major portion of the tripping and pollination of alfalfa was accomplished by wild bees.

(3) In the Palo Verde Valley, 12 species of wild bees were found tripping and pollinating alfalfa. Of these, *Nomia peninsularis* was the most abundant and was found in every field.

(4) In the Hemet Valley, 19 species were found. Of these, *Melissodes timberlakei*, various species of *Megachile*, *Nomia melanderi*, and *Anthidium edwardsii* were probably the most important. No single species was found in every field.

(5) In the northwest portion of the San Joaquin Valley (Tracy-Patterson area), 14 species were encountered, of which *Melissodes timberlakei* appeared to be by far the most important, followed closely by *Megachile brevis*, *M. onobrychidis*, and *Anthidium edwardsii*.

(6) In the delta area of the Sacramento Valley (Ryer Island), 13 pollinators were present, of which *Melissodes timberlakei* and various species of *Megachile* were again the most important.

(7) Honeybees were present in varying numbers in all of the fields but both the percentage and total numbers of pollen-collectors compared unfavorably with the solitary bees. Bumblebees, although individually more efficient than honeybees, were inferior to other wild bees and were usually not abundant enough to be regarded as important factors in alfalfa pollination.—11-27-45.

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Factors Involved in the Separation of *Macrocentrus ancylivorus* Cocoons from Tuber Worm Pupae

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In 1944 Finney *et al.* reported a method for the mass production of *Macrocentrus ancylivorus* Rowher with the potato tuber moth, *Gnorimoschema operculella* (Zell.) as a host. Their separation of the host from the parasite was accomplished by the emergence differential of the moth and parasite adults (Finney *et al.* 1945).

This method of separation became historical when Bartlett & Martin (1945) reported in a scientific note that a solution of sodium hypochlorite would dissolve the silk of the tuber moth cocoons and free the parasite cocoons and host pupae. Finney (1945) reported that the parasite and host could be separated in ethyl alcohol.

Some losses in the number of parasites produced were encountered during the inauguration of the use of sodium hypochlorite and alcohol in the separation of the parasite from the host. The major factors contributing to these losses were mechanical injury, the toxicity of chlorine in decomposing solutions of sodium hypochlorite, toxicity of alcohol, and the loss of parasitized host larvae in the separation baths because of late cocooning of some of the parasite larvae. Techniques which were used to overcome these losses, or to reduce them to a minimum, are reported here.

MECHANICAL INJURY.—Early in the 1945 season the average monthly mortality for *Macrocentrus ancylivorus* stages (larvae, prepupae, and pupae) in the separated cocoons was 40 per cent with a range of 9 to 78 per cent. As experience was gained and methods were improved, the monthly average mortality was reduced to the normal 20 per cent with a range of 5 to 60 per cent. Much of this improvement was due to corrections in the handling of the cocoons.

There were two sources of mechanical injury during the handling of the cocoons. One was due to covering the bottoms of the cocooning trays with a layer of sand approximately ½ to 1 inch deep. This was an excessive amount since the larvae began cocooning at the top and rarely reached the bottom of the layer. The sand had to be sifted from the cocoons to avoid the accumulation of it in the sodium hypochlorite solution. Later the minimum amount of sand needed was poured in adjacent ridge-rows 2 inches wide and ⅜ inch high at the peak of the ridge. Then the larvae cocooned at the bottom as well as at the top surface of the sand. This resulted in a mat of cocoons with little or no excess sand.

The second type of mechanical injury occurred during the treatment of the cocoons in the sodium hypochlorite and the alcohol and water baths. The early techniques involved first treating the host cocoons in sodium hypochlorite in a container with a screen bottom, and then transferring the freed parasite cocoons and host pupae through a funnel and an L-shaped pipe to a trap-bottomed vessel for separation of the two stages in alcohol. The source of injury was the dropping of the cocoons into the funnel and washing them through the pipe.

Such technique was improved by using the same container for both freeing and separating. This basket was 13 inches high and 11 inches in diameter. It was fitted with a trap-bottom by hinging two half-moon-shaped doors to a narrow strip of metal fastened across the bottom. A flexible Y-shaped harness of heavy wire

was connected to a ring centered near the outside edge of each door so that they could be raised and lowered as needed.

The basket used to catch the host pupae and the host and parasite larvae was 13 inches high and 13 inches in diameter. The frames of both vessels were made of bronze welding rods and covered with 14-mesh copper screen.

The procedure for freeing and separating the parasite and host is begun by filling the trap-basket with host cocoons to a depth of 3 inches. The cocoons are immersed in the sodium hypochlorite solution and kept agitated by gently swirling the basket until the parasite cocoons and pupae are free. The silk of the host cocoons dissolves, and the loose sand drops through the meshes of the wire screen to the bottom of the sodium hypochlorite container. In stable solutions the host cocoons are completely disintegrated in 20 to 30 seconds.

The parasite cocoons and host pupae are rinsed for 15 or 20 seconds in a container of tap water. Spraying with water from the tap is a source of mechanical injury. The basket is drained thoroughly so as to avoid dilution of the alcohol.

After rinsing, the trap-basket is lowered inside the large basket which is set in the container of alcohol. The trap doors are dropped to permit the host pupae to fall into the larger basket. Some host pupae intermingle with the parasite cocoons on the surface of the alcohol. These will sink when the mixture is stirred by hand. The pupae which persist in floating do not usually emerge. Separation is complete within 20 to 30 seconds.

After separation the trap-basket is raised high enough in the alcohol to prevent the host pupae from drifting back into the container and the doors are closed. The basket, which now contains only parasite cocoons, is removed from the alcohol. The unrinsed cocoons are spread thinly over a cloth-covered frame and quickly dried before an electric fan.

The host pupae can accumulate on the bottom of the large basket in the alcohol as long as an hour without any apparent effect upon the emergence of the moths. They are dried without rinsing.

The host larvae and parasite larvae which also accumulate in the alcohol can be separated from the host pupae in a used solution of sodium hypochlorite. The larvae will sink while the pupae will continue to float.

Table 1.—Effect of stable and decomposing solutions of 1 part 21 per cent sodium hypochlorite and 5 parts water on the mortality of *Macrocentrus ancylivorus*.

Solution Data		Per Cent Dead			Average Mortality, All Lots
Time to disintegrate host cocoons	Temperature	Average per 100 cocoons	Range for lots of 50 cocoons Min.	Max.	Per Cent
		Stable Solutions			
25 seconds	78° F.	14	12	16	
25 seconds	78° F.	14	8	22	
25 seconds	78° F.	12	8	17	14
25 seconds	78° F.	16	14	18	
		Decomposing Solutions Releasing Chlorine			
60 seconds	90° F.	81	76	86	
60 seconds	90° F.	60	52	68	
40 seconds	83° F.	40	31	49	47
40 seconds	83° F.	26	20	32	
30 seconds	83° F.	30	26	34	
		Decomposing and Stable Solutions[1]			
15 sec. and 30 sec.	92° F. 80° F.	41 45	38 40	44 50	43
		Untreated Checks			
Parasite cocoons dissected from host cocoons		12 14	10 10	14 18	13

[1] Four lots of 50 cocoons dipped in decomposing solution for 15 sec. and the freeing completed in stable solution.

SODIUM HYPOCHLORITE TOXICITY.—Bartlett & Martin (1945) reported that the eclosion of neither the parasite nor the moth seemed to be affected by sodium hypochlorite. Further experiments show that stable solutions of sodium hypochlorite are not toxic to *Macrocentrus ancylivorus* stages in the cocoons but decomposing solutions are partially toxic. This is shown by the data in table 1 where there is a comparison of the mortality obtained with stable and decomposing solutions and untreated checks.

While these data, table 1, are for a solution of one part of 21 per cent sodium hypochlorite diluted with five parts water, solutions as strong as one part sodium hypochlorite in three parts water can be used. However, it is more economical to use the former dilution.

The average mortality with stable solutions in the insectary was 18 per cent with a range of 5 to 25 per cent. This average does not differ from the mortality of untreated cocoons. The disease which the *Macrocentrus ancylivorus* larvae contract from the tuber moth larvae is the cause for much of the mortality represented by this average.

The decomposition of the sodium hypochlorite solution began after certain quantities of organic materials had collected in the bath. Two sources of organic debris were dead host larvae and the dissolved silk of the host cocoons. At times the sand itself contained organic material before it was put in the cocooning trays. The fourth and a major source was the varying amounts of potato tuber moth larval-frass which became dislodged from the surface of the potatoes and fell into the cocooning sand.

One indication of decomposition was the increase in the time of disintegration of host cocoons. At the same time the temperature of the solution rose above the original temperature. Sometimes this rise was as much as 10° F. or higher. Also, sufficient quantities of chlorine were released from the solution to irritate the eyes and throat of the operator.

The average mortality of the *Macrocentrus ancylivorus* stages in cocoons freed in decomposing solutions of sodium hypochlorite was not only higher than in stable solutions, but the range was much wider, table 1. This variability may be related to the rate of decomposition which in turn is correlated with temperature. Mortality was the highest in the warmest solutions. An immersion of only 15 seconds in a warm decomposing solution was sufficient time to cause considerable mortality.

There was a period in the insectary when on some days part of the lot of cocoons was freed while the solution of sodium hypochlorite was stable and the rest of the lot was freed as the solution progressed in decomposition. On other days entire lots were freed in stable solutions. During this period the mortality ranged from 5 to 60 per cent. Evidently the low mortality represented lots from stable solutions while the higher mortality represented lots freed in solutions which were stable at first but later became more and more decomposed.

When *Macrocentrus ancylivorus* cocoons were rinsed in water, there were not sufficient quantities of sodium hypochlorite left on the surface of the cocoons to produce toxic effects, even when an undiluted solution was used (Table 2).

Table 2.—Toxicity of sodium hypochlorite residue on the surface of *Macrocentrus ancylivorus* cocoons.

TREATMENT	NUMBER LOTS OF 100 COCOONS	PER CENT AVERAGE MORTALITY PER LOT	
		Rinsed in water	Unrinsed
1 part sodium hypcohlorite in 5 parts water	4	15	16
Undiluted sodium hypochlorite	4	15	85
Untreated checks dissected from host cocoons	4	—	18

Toxic effects were obtained only when an undiluted solution of sodium hypochlorite was permitted to dry on the cocoons without rinsing, (Table 2). Under these conditions the corrosive residue etched holes through the walls of the cocoons.

It is good practice to rinse the cocoons to prevent a chemical reaction between sodium hypochlorite and alcohol.

The following observations indicate that the chlorine in the decomposing sodium hypochlorite solution is the toxic agent which penetrates the parasite cocoons rather than liquids.

The number of dry parasite cocoons where in the stage died greatly exceeded the very small numbers of water-logged cocoons. The latter seemed to be thin-walled and frequently abnormal in color.

When *Macrocentrus ancylivorus* cocoons are immersed in a sodium hypochlorite solution and rinsed in water, 50 per cent or more usually have small bubbles of liquid in the outermost layers of the cocoon. After immersion in alcohol the number of cocoons with droplets decreases. The bubbles may disappear within 24 hours, or they may yet be present in the walls of the cocoon after the adult has emerged. Repeated observations indicate that these droplets do not usually penetrate inside the cocoon, even when the area around them is gently stroked with a dissecting needle. The mortality for stages in 400 cocoons with droplets was no greater than for the same number without them.

Chlorine in the air will penetrate and cause a mortality of the stages in the cocoons. This was demonstrated by first dropping tuber moth larval-frass from potatoes into a beaker of sodium hypochlorite to release chlorine fumes. There was a 100 per cent mortality in parasite cocoons held ½ inch above the solution for a minute. Cocoons held over stable solutions were not affected.

ALCOHOL TOXICITY.—The specific gravity of ethyl alcohol and water was correlated with the mortality of *Macrocentrus ancylivorus* stages in the cocoons. As table 3 shows, when the specific gravity was .900 to .930 (Baumé), the mortality differed but slightly from the untreated checks. However, mortality was four times greater than the check when the specific gravity ranged .840 to .855.

Table 3.—Correlation of *Macrocentrus ancylivorus* mortality with the specific gravity of ethyl alcohol and water.

Specific Gravity of Alcohol and Water (Baumé)	Number Lots of 100 Cocoons Each	Per Cent		
		Average mortality per lot	Mortality range	
			Min.	Max.
.840–.855	10	45.6	36	64
.900–.930	20	13.5	6	20
Untreated checks	12	10.8	7	18

In the insectary an alcohol and water bath with a specific gravity of .920 was used to separate the parasite cocoons from the host pupae. Separation was more efficient at this than at .930.

TIMING SEPARATION OF PARASITE FROM HOST.—During the early part of the pupal period of the tuber moth the newly-formed yellow pupae will readily sink in the alcoholic solution. After they become black in color and air begins to infiltrate around the nearly mature adult, the pupae float on the surface of the alcohol. This begins to happen before all the parasites have spun cocoons. Because the parasites and pupae should be separated before the latter floats, varying numbers of parasites are lost.

Data have been collected to determine the degree of losses of parasites at the time of separation of parasite and host, and if there was a relation of the losses to some routine practices involved in collection and separation. Cocoons of larvae which had emerged for intervals of 8 to 48 hours from one lot of White Rose potatoes dug in May, were removed over a period of 9 successive days. These had been exposed to 75 *Macrocentrus ancylivorus* females for a period of 5 days after the females were released in each tray of potatoes 1 day after the hatching of the tuber moth eggs. Records of the total number of moth pupae, parasite cocoons, and late cocooning parasites per collection date were taken when the host cocoons were 4 to 8 days old (Table 4). The late cocooning parasites included both parasitized host larvae and free parasite larvae.

The percentage of parasitism increased with each successive collecting date until the sixth day (Table 4). Then the parasitism became more or less stable. There was no period when only unparasitized larvae emerged from the potatoes.

The rise and fall of the emergence of parasitized and unparasitized moth larvae followed very similar trends (Table 4). Both reached peaks on the fifth day of collection and followed similar emergence oscillations independent of temperature and light. The lowest numbers emerged between 4 P.M. and midnight.

Thirteen per cent of the total number of parasite larvae recorded in table 4 were lost when the parasite cocoons were separated from the host pupae. Nearly all the parasite larvae would have cocooned by the time the host cocoons were 10 days old. This loss was representative of those encountered in the routine of production during the early part of the season. No method has been devised to save these parasites after they have been separated from the host cocoons.

Table 4.—Number of hosts and parasites obtained on successive days from one lot of potatoes and the per cent of late cocooning larvae and the per cent parasitism.

Successive Days Host Cocoons Were Collected	Time Tray Was Under Potatoes	Age of Host Cocoons When Examined (Days)	Total Number			Per Cent	
			Tuber moth pupae	Parasite cocoons	Late cocooning parasites	Late cocooning parasites	Host parasitism
1–2	48 hrs.	7 and 8	4070[1]	1960	570	22	39
3	8 A.M.–4 P.M.	6	1485	1075	340	24	48
	4 P.M.–8 A.M.	7	2050	2500	100	4	56
4	8 A.M.–4 P.M.	6	1740	4300	160	3	72
	4 P.M.–12 M.	6	1015	2485	100	4	72
	12 M.–8 A.M.	6	2345	5475	80	1	70
5	8 A.M.–4 P.M.	5	3427	9740	133	1	74
	4 P.M.–12 M.	5	1150	3820	230	6	78
	12 M.–8 A.M.	5	2280	5870	150	2	72
6	8 A.M.–4 P.M.	5	1450	7000	1050	17	77
	4 P.M.–8 A.M.	5	1000	5500	2000	27	88
7	8 A.M.–4 P.M.	4	400	3500	1800	34	93
	4 P.M.–8 A.M.	5	670	2650	580	18	83
8	8 A.M.–4 P.M.	5	260	2360	580	20	92
9 and 9	40 hours	7	130	443	300	34	85

[1] 1–2 per cent emergence of adult tuber moths.

Late cocooning of the parasites was not correlated with an 8-hour or 24-hour collecting interval of the host cocoons, table 4. The host cocoons were collected every 24 hours in the insectary.

The emergence of the late cocooning larvae followed an irregular but similar trend to the normal cocooning parasite larvae. The abrupt peak appeared a day after the peak of the earlier cocooning parasites. Part of the larvae collected on the seventh day were taken from the host cocoons too early.

One of the causes of late cocooning of *Macrocentrus ancylivorus* is superparasitism. Evidence of this is shown in table 5 for data obtained with freshly dug White Rose potatoes which were infested in May and June 1945. These data show a close correlation between the percentage of parasitization, the percentage of late cocooning parasite larvae, and the number of parasite larval head capsules per host.

The head capsule data show some superparasitism at the end of 24 hours, and 50 per cent or more of the host larvae were infested with two to 28 parasites by the end of 72 hours.

Daniel (1932) observed that although *Macrocentrus ancylivorus* is a polyembryonic parasite only one individual matures, while the development of the associated embryos is stopped by some secretion of either the host or the parasite. He also observed that in case of two or more first instar larvae in the host, only one survived because of cannibalism.

There is evidence that under the influence of superparasitism some secretion of either the host or parasite may partially inhibit the development of the surviving parasite larva. The degree to which its development is inhibited depends upon the degree of superparasitism.

Many of the more highly parasitized host larvae were slightly to extremely misshapen because of the loss of muscular tonus. This may be related either to a secretion associated with superparasitism or to the parasite larvae mechanically injuring the nervous system of the host.

The degree of clearing of the internal contents of the host with a saturated solution of chloral hydrate and benzene is indicative of a secretion associated with superparasitism. While hosts infested with two or three head capsules of *Macrocentrus*

Table 5.—Effect of superparasitism by *Macrocentrus ancylivorus* on the per cent of parasite larvae delaying cocooning and upon tuber moth populations.

Date of Initial Parasitization	Days 100 Females in Tray	Total Host Larvae per Tray	Per Cent		Number Parasite Head Capsules in Each Host				
			Parasitism	Late cocooning larvae	0	1	2–28	Total head capsules	Ave. head capsules, per host
					Number Hosts				
May 14	1	5000	55	14	6	32	12	66	1.3
	2	4480	77	14	3	24	23	132	2.6
	3	4675	88	26	2	20	28	213	4.2
	4	4295	80	31	1	19	30	136	2.7
	5	2100	93	54	2	18	30	150	3.0
June 17	1	2130	53	3	2	59	89	401	2.6
	5	845	94	20	4	17	129	590	3.9
	5[1]	282	89	15	3	10	87	740	7.4

[1] 400 female parasites in tray.

ancylivorus usually clear within an hour, yet the misshapen hosts with larger numbers of parasite head capsules usually remain cloudy to various degrees. In one extreme case a host with 57 head capsules did not clear to any degree after several days of soaking. The contents of its body remained cottony-like in appearance and consistency.

The degree of superparasitism in the insectary was similar to the data presented in tables 4 and 5. At the time these data were collected the adult females of *Macrocentrus ancylivorus* were kept in the trays of infested potatoes for 5 days. When the parasitization period was reduced to 3 days, the misshapen larvae, which were common earlier, disappeared. Also the losses in the alcohol and water separation bath were reduced to 5 per cent.

More parasites were produced with a 3-day inoculation period than with a 5-day period. This is shown in table 5 where the number of hosts per tray was sharply reduced from the fourth to the fifth day. Finney *et al.* (1945) reported destruction of tuber moth larvae by parasitization.

When old White Rose potatoes replaced the freshly dug stock in the fall, the tuber moth larvae were able to spend more time feeding in the pith of the potato rather than on the surface. With this change in the feeding habits of the host, parasitization was reduced considerably and the losses of parasites from delayed cocooning almost vanished.

It is necessary to separate parasites and hosts after the host cocoons have been held 6 to 7 days at 84° F. because the prepupal and early pupal stages of the parasite are more likely to be injured during the handling in the chemical baths than the older pupal stage. There was less mortality when 75 per cent of the stages were pupae than when 35 per cent were pupae (Table 6).

Table 6.—Mortality of stages of *Macrocentrus ancylivorus* when the cocoons contained low and high percentages of pupae.

Per Cent Pupae	Lots of Cocoons	Larvae		Prepupae		Pupae	
		Total	Per cent dead	Total	Per cent dead	Total	Per cent dead
		Cocoons passed through separation baths					
34.3	6	70	34.3	314	44.0	201	26.3
75.7	11	25	27.9	280	21.0	763	10.7
		Untreated check lots					
63.3	6	36	22.2	185	25.1	380	9.5

SUMMARY.—Studies show that with proper precautions, there is no mortality of the stages of *Macrocentrus ancylivorus* Rowher in the cocoons resulting from the process of freeing them from host cocoons and separating them from the host pupae. Such precautions include elimination of mechanical factors by the proper sanding of the cocooning trays and the proper use of a trap-bottomed vessel for the freeing and separation of the parasites from the hosts. Toxicity factors are avoided when only stable solutions of sodium hypochlorite are used for freeing and alcohol with a specific gravity of .920 (Baumé) is used for separation.

Since the parasites must be separated from the host pupae before the latter float, superparasitized host larvae are lost, although the parasites would have eventutally emerged from them. Superparasitism can be reduced by exposing the hosts for 3 days. Freeing and separating the parasites is done when the host cocoons are 6 to 7 days old. The date of freeing is dependent on the time when 75 per cent of the parasites have pupated.—12-27-45.

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Feeding Chemicals to Plants and Animals for Pest Control

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There are two methods of applying chemicals for the control of injurious insects that have received very little notice but which merit further consideration. One of these methods is the internal administration of drugs to animals for the control of their external parasites. The other is the injection of chemicals into the sap stream of plants in order to kill the insects feeding on these plants. These methods are analogous and constitute a procedure of combating external parasites by inner therapy.

INTERNAL MEDICATION OF ANIMALS.—Until recently it was believed that no chemical administered internally could protect animals from external parasites. Parman *et al.* (1928) reported the results of comprehensive experiments which showed that the external parasites of the hen are not adequately controlled by internal treatment with chemicals commonly sold for that purpose. The following chemicals were tested: Magnesium sulfate (Epsom salt), sodium carbonate, naphthalene, calcium thiosulfate, calcium sulfate, calcium sulfide, magnesium oxide, sodium sulfate, potassium nitrate, ferric oxide, ferric sulfate, ferrous sulfate, potassium tellurate, potassium tellurite, diethyl diselenide, sodium nitrate, tartar emetic, potassium iodide, sulfur, potassium bitartrate, potassium carbonate, capsicum, gentian, ginger, fenugreek, garlic, camphor, tobacco (1.08 per cent nicotine), quinine sulfate, and nux vomica.

Parasites infesting these hens included body, shaft, and head lice, scaly-leg and red mites, ticks, and sticktight fleas.

Weighed doses of chemicals were administered in small gelatin capsules. All the parasites fed freely on the medicated hens, and apparently there was no repellent effect. All species that were tested reproduced and developed in a normal manner, and in no case was any deleterious effect observed in any generation.

Additional experiments were made with proprietary products containing lime-sulfur solution, elemental sulfur, ferrous sulfate, Epsom salt, nux vomica, mustard, and red pepper. In these tests the parasites included body, shaft, wing, and large hen lice and red mites.

Not one of the preparations, when given in the food or drinking water, showed any indications of value against the parasites used.

It may be pointed out that many of the materials used in these tests, such as Epsom salt and nux vomica, have been shown to have little insecticidal action on any species of insect, and that some of the other materials which are insecticides, such as naphthalene and sulfur, are effective against a limited range of insects and in certain ways only, *e.g.*, naphthalene when used as a fumigant and sulfur when applied as a contact poison.

Recent reports of tests with other chemicals as internal remedies for external parasites compel us to change our opinion as to the ineffectiveness of this method of control. Lindquist *et al.* (1944) reported that mortality as high as 100 per cent occurred when bedbugs were allowed to feed on a rabbit 3 to 5 hours after DDT was administered in doses from 228 to 400 mg. per kilogram of body weight. Because of the method of administration the mortality can be attributed only to ingestion by the bug of the insecticide present in the blood or tissues of the host. Pyrethrum extract gave similar results not only with bedbugs but also with stableflies.

Also of interest is the finding by Knipling (1938) that phenothiazine fed to cattle at the rate of about 100 mg. or less per kilogram of body weight prevented development of horn fly larvae in the manure that was eliminated by such animals. Bruce (1939) reported additional studies in which it was found that as little as 22 mg. of phenothiazine per kilogram of body weight rendered the manure unfavorable for the development of horn fly larvae for approximately 24 hours, beginning 12 hours after oral administration.

These findings open up a field of research that has scarcely been touched during the past 20 years, and which promises to yield results of great value. There are innumerable organic compounds that should be tested by feeding to animals to see if they control the external parasites of these animals or the insects breeding in the manure from them.

Thousands of synthetics have been prepared and tested as toxicants in kerosene housefly sprays and are available for testing in other ways. Now that we know that compounds insoluble in water (such as DDT, phenothiazine, and the pyrethrins) may prove effective when fed to animals, our horizon is greatly expanded. We do not need to consider solubility in water as an indispensable property that must be possessed by a compound before it can be used in internal medication.

INJECTIONS OF CHEMICALS INTO PLANTS —The injection of chemicals into trees and growing plants for the control of parasitic insects and fungi was first proposed many years ago, but because of failure to get results with the compounds tried this procedure fell into disrepute. Illustrative of this attitude is the title "Good fiction, poor horticulture" that Messenger (1920) used in an account of tree injection. Entomologists testing the claims made for tree injection reported negative results. For example, Flint (1915) injected potassium cyanide into bore holes in locust trees, but he noted no apparent control of the locust borers and many trees died from the treatment.

A large number of chemicals have been injected into trees. Rumbold (1920) used the following in attempts to find a cure for the blight of chestnut trees: Copper sulfate, copper chloride, zinc carbonate, mercuric chloride, potassium chromate, potassium dichromate, barium chloride, colloidal cuprous hydroxide, colloidal metallic silver, potassium carbonate, potassium hydroxide, potassium sulfate, ammonium carbonate, ammonium chloride, ammonium hydroxide, ammonium sulfate, sodium carbonate, sodium chloride, sodium hydroxide, lithium carbonate, lithium chloride, lithium sulfate, lithium hydroxide, lithium nitrate, methyl alcohol, formalin, acetic acid, formic acid, lactic acid, citric acid, aniline sulfate, phenol, sodium carbolate, para-nitrophenol, ortho-nitrophenol, picric acid, meta-cresol, para-cresol, thymol, pyrocatechol, pyrogallic acid, phloroglucinol, oil of bitter almonds, benzoic acid, salicylic acid, bark extracts, water extract of chestnut tree bark, water extract of chestnut blight canker, methyl green, methylene blue, eosin, congo red, and trypan blue. These chemicals proved ineffective and some of them injured the trees.

When the objective in tree injection was to kill bark beetles or other insects and

to preserve the wood but not to maintain the tree in a healthy growing condition, Craighead & St. George (1938) found several chemicals to be effective. Among these were zinc chloride, copper sulfate, mercuric chloride, zinc meta-arsenite, sodium arsenate, sodium arsenite, sodium fluoride, ammonium bifluoride, and ammonium copper arsenite. Additional chemicals that have been used in treatments of trees by injection have been listed by Carter (1939) and Wilford (1944).

There are several possible reasons for the failure of a chemical injected into a tree to kill insects feeding on the tree. The chemical may be precipitated in the sap stream and fail to be distributed, it may be distributed in an altered, nontoxic form, or the dosage applied may be too low. More important reasons for such failure are that the chemical was toxic to the tree, and that it was not toxic to the species of insect at which control was aimed.

Mercuric chloride, potassium dichromate, sodium arsenite, and ammonium bifluoride—to name only a few of the chemicals tested for tree injection—are caustic poisons. They are toxic to both animal and plant tissues, and it is not surprising that they kill a tree when injected into it.

The successful control of insects on plants by allowing the plants to take up a water-soluble insect poison is described by Hurd-Karrer & Poos (1936), who found that the apple-grain aphid feeding on wheat, rye, oats, and barley is killed by the selenium taken up by these plants from small amounts of sodium selenate added to cultures or soils. Aphids placed on 2-month-old wheat plants supplied with concentrations of selenium greater than 3 ppm. all died within a few days, while those on plants given lower concentrations lived for as long as a week, although without reproducing actively. Similar results were observed with the red spider. The plants were stunted by concentrations of selenium greater than 3 ppm. It has been suggested that aphids and other insects attacking trees might be controlled by the injection of soluble selenium compounds into the sap stream. Because selenium is highly poisonous to man and other mammals, this suggestion has never been followed up.

Many chemicals have been injected into trees to control species of insects not susceptible to that chemical no matter how applied. The Japanese beetle, for example, is not controlled by the direct application of dusts or sprays containing nicotine or any of its salts. It would therefore appear useless to attempt to control the Japanese beetle by injecting nicotine or any of its salts into a plant on which the beetle feeds.

The injection of a material into a plant would appear to have a greater chance of success if the material were known to be toxic to the insect to be controlled.

Fulton & Mason (1937) reported that derris constituents were translocated from the outer surfaces of leaves to first, second, and third trifoliate leaves formed after the application of derris powder in water suspension to the first true leaves and stems of bean plants. These trifoliate leaves were found to be less palatable to Mexican bean beetle larvae than were similar leaves from untreated plants. The feeding of the larvae was definitely retarded. It would have been interesting to learn whether derris extractives injected into the sap stream of a bean plant would poison bean beetle larvae feeding on the plant. Fulton & Mason's finding that derris constituents, compounds highly insoluble in water, can be translocated in a bean plant suggests that other insoluble compounds can be translocated in plants. No longer does it seem necessary for the experimenter desiring to test chemicals for tree injection to limit his tests to those readily soluble in water.

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Benzene Hexachloride to Control Cotton Insects

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Benzene hexachloride dusts were tested against seven of the more important cotton insects at Waco, Texas, during 1945. Most of these tests consisted of laboratory and cage experiments designed to establish the fact of toxicity and to determine the effective dosage against various insects.

The procedure previously described, of placing a dusting chamber over plants to be dusted (Ivy 1944), was used in conducting the laboratory and cage tests, except that in the cage tests air from a tank of compressed air at 60 to 80 pounds pressure was used as a dust propellant instead of air from an automobile-tire pump.

The benzene hexachloride dust used in these tests was prepared by the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine, by milling British benzene hexachloride containing approximately 35 per cent of the gamma isomer with sufficient talc to give a final gamma-isomer content of 10 per cent. The concentrations below 10 per cent were prepared at the Waco laboratory by diluting the 10 per cent dust with pyrophyllite. The concentrations given for benzene hexachloride refer to the gamma-isomer content of the dust.

Dosage-control curves for five of the insects tested are given in figure 1. The procedure of Bliss (1935) was used in computing the curves.

The various tests are discussed briefly under the insects used, and the results are shown in tables 1 to 3. Comparable tests of standard insecticides and untreated check cages were run concurrently with these tests. With the important exception of the bollworm, the results with benzene hexachloride were equal or superior to those obtained with the best-known insecticides, such as calcium arsenate, sulfur, DDT, and nicotine.

BOLL WEEVIL, *Anthonomus grandis* BOH.—Benzene hexachloride was more effective and gave a much quicker kill of boll weevils than did calcium arsenate treatments.

In a field-plot experiment August-planted cotton was dusted on October 17. Two dusted plots and an undusted check plot were each 12 rows wide and 0.025 acre in size. Two days after one plot had been dusted at the rate of 11.6 pounds per acre with benzene hexachloride containing 10 per cent of the gamma isomer, the adult weevil population was found to be reduced 59 per cent. No reduction had occurred in an adjoining plot treated at the rate of 17.2 pounds per acre with a calcium arsenate dust containing 2 per cent of nicotine.

COTTON LEAFWORM, *Alabama argillacea* (HBN.).—Ten-per cent benzene hexachloride was very effective against third-instar larvae. It gave a much quicker kill than calcium arsenate. At concentrations lower than 10 per cent, however, its effectiveness was materially reduced.

BOLLWORM, *Heliothis armigera* (HBN.).—A 10-per cent dust was not very effective against third-instar bollworm larvae. Even at the rate of 32 pounds per acre the control was less than that obtained from 5 per cent DDT-pyrophyllite or calcium arsenate each at 16 pounds per acre.

[1] In cooperation with the Texas Agricultural Experiment Station.

Table 1.—Mortality of several cotton insects following dust applications of various dosages of benzene hexachloride in comparison with other insecticides.

Treatment	Concentration of Active Ingredient	Dosage of Dust	Insects Tested	Mortality		
				After 1 Day	After 3 Days	After 5 Days
	Per cent	*Pounds per Acre*	*Number*	*Per cent*	*Per cent*	*Per cent*
			Boll weevil adults			
Benzene hexachloride	10	32	474	34	86	95
		16	458	25	73	88
		8	473	20	64	79
Calcium arsenate	—	8	455	6	35	70
			Cotton leafworm third-instar larvae			
Benzene hexachloride	10	32	92	83	100	100
		16	94	80	99	100
		8	176	56	96	98
	5	8	95	14	65	73
	2.5	8	91	4	40	44
	1.25	8	85	5	28	35
Calcium arsenate	—	8	177	32	93	96
			Bollworm third-instar larvae			
Benzene hexachloride	10	32	36	14	58	70
		16	35	11	31	39
		8	31	6	29	32
DDT-pyrophyllite	5	16	39	26	85	97
Calcium arsenate	—	16	36	19	64	85
			Tarnished plant bug adults			
Benzene hexachloride	10	16	10	100	100	100
	5	16	10	100	100	100
	2.5	16	13	69	100	100
	1.25	16	14	71	100	100
	0.62	16	13	62	85	92
DDT-sulfur	4.6[1]	16	9	100	100	100
			Tarnished plant bug nymphs			
Benzene hexachloride	5	16	11	45	100	100
	1.25	16	13	23	85	100
			Southern green stinkbug adults			
Benzene hexachloride	10	32	25	48	64	68
		16	22	23	59	59
		8	32	16	38	47
DDT-pyrophyllite	10	16	27	7	37	63
			Southern green stinkbug second-instar nymphs			
Benzene hexachloride	10	32	41	71	90	95
		16	29	28	66	86
		8	26	19	73	88
DDT-pyrophyllite	10	16	30	17	100	100
			Southern green stinkbug fifth-instar nymphs			
Benzene hexachloride	10	32	22	9	14	14
		16	26	12	23	31
		8	24	4	4	4
DDT-pyrophyllite	10	16	23	0	0	13

[1] Concentration of DDT.

TARNISHED PLANT BUG, *Lygus oblineatus* (SAY).—The control of this insect was excellent. Concentrations as low as 1.25 per cent gave 100 per cent control of both adults and nymphs.

SOUTHERN GREEN STINKBUG, *Nezara viridula* (L.).—Ten-per cent benzene hexachloride was approximately as effective as 10-per cent DDT-pyrophyllite. Both materials gave good control of second-instar nymphs, fair control of adults, and poor control of fifth-instar nymphs.

Table 2.—Mortality of cotton flea hopper adults following dust applications of benzene hexachloride and DDT. (All dosages 16 pounds per acre.)

Treatment	Concentration of Active Ingredient	Flea Hoppers Tested	Mortality 24 Hours After Treatment
	Per cent	*Number*	*Per cent*
	Series 1		
Benzene hexachloride	10	31	100
DDT-pyrophyllite	5	28	61
	Series 2		
Benzene hexachloride	10	45	100
	5	48	100
	2.5	44	100
	1.25	43	100
DDT-sulfur	4.6[1]	52	100
	Series 3		
Benzene hexachloride	5	52	100
	2.5	61	98
	1.25	49	93
	0.62	40	92
	0.31	45	83
DDT-sulfur	4.6[1]	44	95
	Series 4		
Benzene hexachloride	1	48	86
	0.3	43	58
	0.1	36	30
	0.03	38	18
	0.01	41	18
Pyrophyllite	—	44	0

[1] Concentration of DDT.

COTTON FLEA HOPPER, *Psallus seriatus* (REUT.).—In concentrations as low as 0.31 per cent benzene hexachloride was very effective against the cotton flea hopper. At lower concentrations it was somewhat less effective. The data on four series of cage tests conducted against this insect are given in table 2.

COTTON APHID, *Aphis gossypii* GLOV.—Details of laboratory and field tests against the cotton aphid are given in table 3. Samples of 8 leaves were used in each treatment in series 1, eight leaves on each of three plants in each treatment in series 2, and 32 leaves scattered at random over each plot in series 3. In laboratory tests (series 1), 10 per cent benzene hexachloride was found to give better

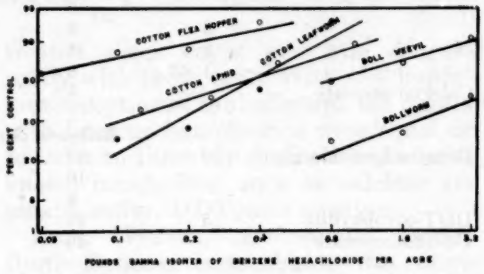

FIG. 1.—Response of several cotton insects to varying doses of the gamma isomer of benzene hexachloride.

Table 3.—Control of cotton aphids following dust applications of various dosages of benzene hexachloride in comparison with nicotine.

Treatment	Concentration of Active Ingredient	Dosage of Dust	Aphids per Leaf Before Treatment	Reduction at Intervals Following Treatment				
				1 Hour	1 Day	2 Days	3 Days	5 Days
	Per cent	*Pounds per Acre*	*Number*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
	Series 1. Aphid-infested leaves treated in laboratory							
Benzene hexachloride	10	40	67	—	89	—	—	—
		30	90	—	82	—	—	—
		20	92	—	85	—	—	—
		10	63	—	79	—	—	—
Nicotine-calcium arsenate	2[1]	10	73	—	71	—	—	—
Untreated check	—	—	73	—	2	—	—	—
	Series 2. Aphid-infested field-growing plants treated in dusting chamber							
Benzene hexachloride	10	10	89	77	94	94	95	95
	5	10	67	61	88	93	93	95
	2.5	10	69	49	66	73	71	74
	1.25	10	71	32	58	63	74	80
Nicotine-calcium arsenate	2[1]	10	62	72	84	75	66	64
Untreated check	—	—	78	1	1	0	−1	−2
	Series 3. Aphid-infested field-growing plants treated with hand dust gun							
Benzene hexachloride	10	11.6	44	—	65	67	—	77
Nicotine-calcium arsenate	2[1]	17.2	48	—	23	21	—	−8
Untreated check	—	—	45	—	5	0	—	−12

[1] Concentration of nicotine.

aphid control than calcium arsenate dust containing 2 per cent of nicotine. In field cage tests (series 2) 5 and 10 per cent benzene hexachloride dusts gave better control 1 day after treatment than the nicotine-calcium arsenate dust, but 2.5 and 1.25 per cent benzene hexachloride dusts were less effective. By the fifth day after treatment, however, the control from all concentrations of benzene hexachloride was better than from the nicotine-calcium arsenate treatment. Nicotine apparently loses its effectiveness within a few hours after application and surviving aphids continue to reproduce, whereas benzene hexachloride continues to kill for a period of several days after application.

In series 3 are given aphid records obtained in the field-plot experiment described under the section on boll weevil, above. In this experiment the continued downward trend of mortality in the benzene hexachloride plot as compared to the upward trend of aphid populations after 5 days in the plot treated with nicotine and calcium arsenate was very striking.

PHYTOTOXICITY.—In only two cage tests was injury to cotton plants noticeable. In those instances injury to tender terminal leaves was noted following heavy spotted applications resulting from improper distribution of 10 per cent benzene hexachloride. No injury was noted at concentrations below 10 per cent or at rates of application lower than 16 pounds of the dust per acre.

SUMMARY.—In laboratory and cage tests at Waco, Texas, benzene hexachloride dust was found to give excellent control of several of the more important cotton insects. Control of the boll weevil and the cotton leafworm was better than with calcium arsenate. Control of the cotton flea hopper, the tarnished plant bug, and the southern green stinkbug was equal to or better than control obtained with DDT. Better control of the cotton aphid, *Aphis gossypii* Glov., was obtained than with nicotine dusts. Poor control was obtained with the bollworm. DDT and heavy dosages of calcium arsenate dusts each gave better bollworm control than benzene hexachloride.—1-14-46.

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DDT to Control Bugs That Cause Deformed Peaches

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The occurrence of deformed peaches in South Carolina orchards has presented a problem in that State for a number of years, especially in Spartanburg County. Visits to orchards near Spartanburg in July 1942 and June 1943 revealed that in some orchards as many as 20 per cent of the peaches were being culled out on account of their distorted and scarred condition. One orchardist at Inman estimated that 40 per cent of his peaches had to be graded out as culls in 1941 for this reason. In most cases the injury was typical of that reported to be caused by sucking bugs. The injury had been begun earlier in the season, and a search in the orchards at the time of the visits failed to reveal the presence of insects of the type believed to be involved.

TARNISHED PLANT BUGS.—On March 22 and 23, 1944, during the blooming period, jarring of peach trees in a Spartanburg County orchard in which serious distortion of peaches had occurred in previous years revealed the presence of the tarnished plant bug, *Lygus oblineatus* (Say),[2] on every tree that was jarred. As many as 7 tarnished plant bugs were taken from a single tree at one jarring, and the average number caught per tree for the two days was also 7. During the same period an average of 2 to 3.3 tarnished plant bugs per tree were jarred from trees in other orchards in this county in which deformed peaches had been common in previous years. On the other hand, jarring on March 23 failed

[1] In cooperation with the South Carolina Peach Growers' Association and the Clemson Agricultural College.
[2] Determined by R. I. Sailer, of the Bureau of Entomology and Plant Quarantine.

to show the presence of tarnished plant bugs in an orchard that had produced very few, if any, deformed peaches in previous years. In 1944 six peach trees in an orchard at Inman were jarred regularly from the blooming season until the stone of the fruit had hardened, to determine how long the tarnished plant bug remains on peach trees and what other bugs may be present. Table 1 gives the results of these jarrings.

Table 1.—Occurrence of bugs on peach trees at Inman, S. C., during the season of 1944, as indicated by jarring.

Date 1944	Tarnished Plant Bugs	Pentatomids	Fruit Development at Time of Jarring
	Number	*Number*	
Mar. 22	20	4	Just past full bloom
23	22	1	
25	39	0	
30	23	2	
April 3	13	0	
6	1	0	Petals 90% off
10	0	0	All petals off April 9
13	5	0	1% of shucks off
17	2	0	60% of shucks off
19	0	0	80% of shucks off
25	3	1	Peaches 0.5 to 0.75
28	0	0	inch diameter
May 2	0	0	
5	0	0	
9	0	0	
15	0	0	
Total	128	8	

These jarring records show that the tarnished plant bug is present in largest numbers on peach trees from the time of full bloom until petal fall. The fact that comparatively few pentatomids were caught indicates that they are not involved in the deformed-peach problem in South Carolina.

Observations in cages showed that newly set peaches were ruined within 7 days by the feeding of plant bugs.

PRELIMINARY CONTROL EXPERIMENT.—A cage test in the spring of 1944 indicated that DDT at the rate of 1 pound to 100 gallons of spray was effective against the tarnished plant bug. Accordingly DDT, applied as a dust, was compared with jarring as a control of sucking bugs that attack peaches in a preliminary orchard experiment at Inman during the season of 1944. Two dusts were used, 5 per cent of DDT in pyrophyllite and kaolin and 10 per cent of DDT in pyrophyllite. The results were taken during the harvest period from July 27 to August 3, and are given in table 2.

The results of this preliminary experiment indicated that DDT shows considerable promise for the control of sucking bugs that cause deformed peaches, and that jarring cannot be depended on to control these insects.

ORCHARD EXPERIMENTS WITH DDT.—Large-scale orchard experiments with DDT were conducted during 1945 in a 22-year-old Elberta peach orchard at Converse, which has had more or less plant-bug injury every year since the trees began to bear. In fact, this orchard was reported to have produced more plant-bug-injured peaches than any other orchard in that locality. When the 1945 tests were started, in March, tarnished plant bugs were recovered from every tree that was jarred in this orchard.

The orchard was divided into five blocks, of which two were dusted with DDT, two were sprayed with DDT, and one was left untreated as a check. The technical DDT available for use in the sprays was difficult to wet. Considerable kneading in water to which sodium lauryl sulfate had been added was necessary to get it into suspension. Each block contained from 201 to 285 trees. As jarrings the previous season had shown the presence of tarnished plant bugs in large numbers at the time of full bloom, the DDT for these tests was applied March 13 and 15, when the trees were in full bloom. The dusts were used at the rate of about 0.2 pound per tree and the sprays at 6 quarts per tree.

Table 2.—Results of DDT-dust and jarring tests for the control of sucking bugs attacking peaches at Inman, S. C., season of 1944.

Treatment	Trees	Harvested Fruit	
		Peaches Examined	Peaches Damaged
	Number	*Number*	*Per Cent*
DDT dusts: 5 per cent on March 23 and 10 per cent on April 19 and May 5	1	1062	3.5
5 per cent on March 23 and 10 per cent on April 19	1	1577	5.2
5 per cent on March 23	1	1729	5.9
Jarred 16 times during period March 22 to May 15	6	9055	10.3
Check (neither treated nor jarred)	6	10378	14.6

The results of the tests were taken at harvest-time, July 18 to 25, when the fruit from 50 record trees, 10 selected at random in each plot, was carefully examined to determine the damage caused by sucking bugs. A summary of the results is given in table 3.

Table 3.—Results of orchard tests with DDT dusts and sprays for the control of sucking bugs attacking peaches at Converse, S. C., during 1945.

TREATMENT	HARVESTED FRUIT	
	Peaches Examined	Peaches Damaged
	Number	*Per Cent*
Dusts:		
5 per cent	7571	7.8
10 per cent	8331	10.7
Sprays (quantities per 100 gal.):		
DDT 1 lb., sodium lauryl sulfate 1 oz.	4345	11.8
DDT 2 lb., sodium lauryl sulfate 2 oz.	4944	11.0
Check (untreated)	4228	42.4

The results from the single application of DDT at full bloom in 1945 are encouraging and considered very good. Dusts containing 5 or 10 per cent of DDT and sprays containing 1 or 2 pounds of technical DDT per 100 gallons of spray were about equally effective.

Although insects do not play an important part in the pollination of the peach, it is recognized that the application of DDT during the blooming season may cause some injury to bees and other pollinating insects. Applications of DDT just before the trees come into bloom are planned for future tests in an effort to avoid injury to pollinating insects.

Part of the block of trees that received the 5 per cent DDT dust was thinned considerably during the stone-hardening period. No thinning was done in the remainder of this block. Counts at harvest-time on five trees that had been thinned showed 8.4 per cent of the fruit deformed, whereas fruit on the trees that had not been thinned was 8.8 per cent injured. Evidently, the number of injured peaches removed in thinning was in proportion to the number present.

SUMMARY.—Deformed peaches caused by sucking bugs are responsible for a large percentage of the cull peaches in many South Carolina orchards, especially in Spartanburg County. The tarnished plant bug, *Lygus oblineatus* (Say), was found on peach trees in Spartanburg County orchards from full bloom until petal fall, and available evidence indicates that it is largely responsible for the deforming of peaches in that country. Other bugs were present in very small numbers only. Preliminary tests indicated that jarring cannot be depended on to control these insects, but that DDT might give control. In subsequent large-orchard tests, a single application of DDT at full bloom reduced plant-bug-injured peaches at harvest from 42.4 per cent to as few as 7.8 per cent. The results of the tests showed little difference in plant-bug control from 5 to 10 per cent DDT dusts used at the rate of about 0.2 pound per tree, or DDT sprays at strengths of 1 or 2 pounds of the technical material per 100 gallons of spray used at the rate of about 1.5 gallons per tree. There was no difference in the degree of control of sucking bugs from 5 per cent DDT dust whether the fruit had been thinned or not.—12-6-45.

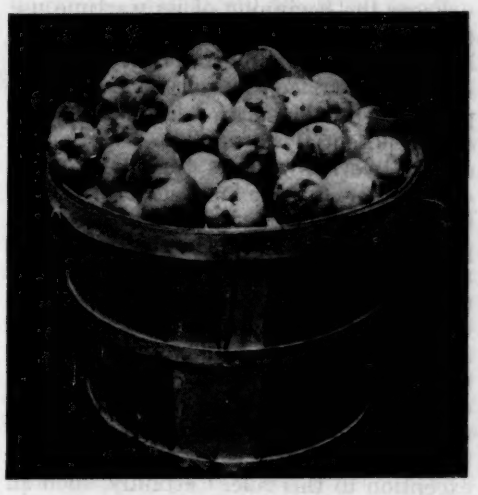

FIG. 1.—Plant-bug-damaged peaches from orchard at Converse, S. C., used for DDT experiments in 1945.

DDT and Its Effect on Fish and Wildlife

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and
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From the beginning of its wartime use the potency of DDT has been the cause of both enthusiasm and grave concern. Some have come to consider it a cure-all for pest insects; others are alarmed because of its potential harm. The experienced control worker realizes that DDT, like every other effective insecticide or rodenticide, is really a two-edged sword: the more potent the poison, the more damage it may be capable of doing. Most organic and mineral poisons are specific to a degree; they do not strike the innumerable animal and plant species with equal effectiveness; if these poisons did, the advantage of control of undesirable species would be more than offset by the detriment to desirable and beneficial forms. DDT is no exception to this rule. Certainly, such an effective poison will destroy some beneficial insects, fish, and wildlife.

Many exploratory investigations were made in 1943 and 1944 by workers in the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture,[1] the U. S. Public Health Service,[2] the U. S. Food and Drug Administration,[3] the Department of Agriculture of Canada and the Royal Ontario Museum of Zoology,[4] the Illinois Natural History Survey,[5] and the University of Missouri.[6] Members of each of these organizations have helped in laying plans for the current year's work. During the same period many popular summaries of the efficiency of DDT have appeared in magazines and newspapers, and a number of articles on its production and use have been presented in trade journals.

The need for more detailed information about the effects of DDT led in 1945 to concurrent studies to determine the effects of this poison upon insects, birds, mammals, fishes, and other wildlife. On areas treated with DDT, members of the Bureau of Entomology and Plant Quarantine (U. S. Department of Agriculture) studied the effects upon insect populations, while representatives of the Fish and Wildlife Service (U. S. Department of the Interior), with the assistance of the U. S. Forest Service, the National Audubon Society, and other organizations, observed the effects upon birds, mammals, fishes, and other forms of wildlife. These investigations were conducted in both field and laboratory, and were concerned primarily with forest insects and forest wildlife.

Most of the poison was sprayed by airplane at rates ranging between 0.2 and 5 pounds of DDT (in an oil solution) per acre. (Most insect pests can be controlled with DDT oil sprays of concentrations ranging from 0.1 to 1 pound per acre.) A single application was the basis for most of these studies. (Repeated applications might have shown more damaging results.) Weather conditions caused considerable variation in the amounts of DDT that actually reached the vegetation; light winds or updrafts sometimes prevented the deposition of small spray particles. In addition, rough topography or paucity of landmarks apparently caused small portions of some areas to be missed or to be covered twice. The measurement of DDT deposition on glass plates, filter paper discs, or on yellow sheets of paper placed on the ground at frequent intervals, constituted the common means by which the actual amount and uniformity of distribution were measured; but such records were

[1] Results of numerous studies on the effects of DDT on insects harmful to man and domestic animals, field crop and forest tree pests, and honeybees were published in the JOURNAL OF ECONOMIC ENTOMOLOGY for February 1944 (Vol. 37, No. 1, pp. 125–59); results of studies on the effects of DDT on livestock, English sparrows and pigeons and on aquatic vertebrates, insects, spiders, snails and crayfish were published in the same journal in August 1945 (Vol. 38, No. 4, pp. 428 and 492, respectively).

[2] Results of several studies on the toxicity of DDT to domestic animals and its use in mosquito control were published in several numbers of Public Health Reports in 1944 and 1945 (Vols. 59 and 60, and supplements).

[3] Results of studies on the toxicity of DDT to laboratory animals were published in Chemical and Engineering News for September 10, 1944 (Vol. 22, p. 1503) and in The Journal of Pharmacology and Experimental Therapeutics for October 1944 (Vol. 82, No. 2, p. 152 and p. 159).

[4] Studies, respectively, on the effects of DDT on insects and on wildlife have been reported upon but not published.

[5] studies on the effects of DDT on fishes and other aquatic animals have been reported upon but not published.

[6] A study of the toxicity of DDT to goldfish and frogs was published in Science for November 24, 1944 (Vol. 100, p. 477).

made on only a very small fraction of the total area sprayed.

The principal field investigations were made in Maryland and Pennsylvania where the studies included insects, mammals, birds, amphibians, and fishes. At the Fish and Wildlife Service's Patuxent Research Refuge, Bowie, Maryland, laboratory studies were made to determine the toxicity of DDT to mammals, birds and amphibians, and at their Fishery Station at Leetown, West Virginia, to determine its toxicity to fishes.

At the Patuxent Research Refuge, habitat and population studies in preceding years had laid a sound base for the evaluation of changes in 1945. In Pennsylvania, before the application of DDT, there was time to become familiar with the environment and to determine the current year's nesting population of birds. Elsewhere the essential preliminary studies were brief or lacking.

This year's work indicates that much remains to be done before the long-time effects of DDT on wildlife can be properly evaluated. The U. S. Public Health Service and the Fish and Wildlife Service have initiated a program to fill in this gap. In the southeastern coastal plain these two agencies are investigating the effect (particularly on aquatic life) of repeated small applications of DDT for the control of the larvae of malarial mosquitoes. The New Jersey Conservation Department has a similar program in relation to the control of pest mosquito larvae. Also, experiments will be undertaken in 1946 to determine the effect on wildlife when DDT is used for the control of orchard or field crop pests, where low to high dosages may be used repeatedly. An effort will be made to determine more precisely the maximum rates of application of DDT that different forms of wildlife can tolerate.

Briefly, wildlife studies have dealt largely with the effect of DDT upon the birds and mammals of a forest area sprayed with that compound, and some studies have dealt with the effects of DDT upon fish. Further, studies are now under way to determine the effects of DDT upon marsh and aquatic organisms, especially on the relation of malarial control to wildlife. Though many more studies are needed in all the above-mentioned fields, it seems that the most pressing requirement for the future is a study to determine the effects of DDT as applied to agricultural crops, to determine the effects of such control practices and procedures upon the wildlife and game dependent upon an agricultural environment. We must remember that about 80 per cent of our game—and a very high percentage of our nongame and insectivorous birds and mammals—are largely dependent upon an agricultural environment. The heaviest and most widespread application of DDT will probably be used in this environment; therefore, it is not improbable that the greatest damage to wildlife will result here. As has been demonstrated in the field of forest-insect control, a well-coordinated study in the application of DDT to agricultural crops will greatly minimize this damage.

PATUXENT (Maryland) RESEARCH REFUGE.—On June 5, 1945, a 117-acre tract of well-drained forest on the Patuxent River bottomland was sprayed by airplane with an oil solution of DDT applied at the rate of 2 pounds per acre. The solution was made of 1 pound of DDT to 2 pints of xylene and 5.7 pints of No. 2 fuel oil; and 2 gallons of the solution were applied to each acre of land. This was not an attempt to control any specific insect; the experiment was conducted solely to determine the effect of DDT on the general populations of both insects and wildlife. Many insects were killed within a few days after the spray was applied; the temporary elimination of adult pest mosquitoes was outstanding. The effects of this application of DDT were not prolonged for most species of insects, however, as most of these species appeared to occur in normal numbers 2 or 3 weeks later.

Two insect-eating mammals, the short-tailed shrew and the deer mouse, were censused on a 10-acre sprayed area and on a similar 10-acre control area a little more than 1 mile from the sprayed tract. Fifty live traps were distributed over these areas, and the animals were trapped, marked, and released from May 2 to May 7. This procedure, with traps placed in the same localities, was repeated on June 14–19, after the spraying.

On the sprayed area 40 deer mice were trapped before and 30 after spraying; on the control area 27 were trapped before and 17 after the date of spraying. The differences on the two areas are not of sta-

tistical significance, and the consistent reductions may be due to seasonal changes in behavior. The number of short-tailed shrews trapped on the sprayed area fell from 23 before spraying to 6 after spraying; on the check area the number fell from 14 before spraying to 8 after spraying. The larger reduction in numbers in the sprayed area is of doubtful statistical significance.

Birds.—A bird census was made during May and June on a 31-acre area within the 117-acre tract of bottomland forest sprayed on June 5. Outside the sprayed tract but within the same large, continuous bottomland forest, two other areas were censused: a 32-acre area 1.12 miles from the sprayed tract, and a 22-acre area immediately adjacent to the sprayed tract. The 32-acre area was used as a control; the 22-acre area was selected to determine whether the spraying caused a marked shift of birds away from the sprayed tract. Before the date of spraying an intensive search was made for nests in the sprayed and in the control areas. During the study each nest was visited daily until the young had left or the nest had been deserted or destroyed.

The census indicated a similar population density in each of the areas before the spraying: 4.1 pairs an acre in the sprayed area, and 3.7 pairs to the acre in each of the others. The commonest species included: red-eyed vireo, redstart, parula warbler, Acadian flycatcher, Kentucky warbler, scarlet tanager, tufted titmouse, ruby-throated hummingbird, and cardinal.

During the first week after the spraying the bird population dropped approximately 12 per cent in the sprayed area, 5 per cent in the control area, and 10 per cent in the area adjacent to the sprayed tract, owing, presumably, to completion of nesting or to loss by predation. These figures are too nearly alike to indicate any effects of DDT. No marked differences in the populations occurred during several weeks after the spraying, and there was no apparently movement away from the sprayed area.

At the time of spraying, nests containing eggs or young were under observation: 23 in the sprayed area and 12 in the control. No difference in hatching or survival was observed on either sprayed or unsprayed areas.

An experiment was conducted to determine whether DDT applied at the rate of 5 pounds an acre to birds' nests, would have any effect upon the hatching of eggs, the development of young, or the abandonment of nests. DDT was applied with a hand atomizer to an area of 1 square foot surrounding and including the nest. Of 34 nests containing eggs, 17 were sprayed and 17 were left unsprayed. Of 39 nests containing young of various ages, 20 were sprayed and 19 were left unsprayed. Insofar as possible, pairs of nests of the same species were compared. The treatment with DDT showed no detrimental effect upon the hatching of eggs or upon the development of young; it caused no abandonment of nests even when they were located in such confined quarters as bird boxes.

Amphibians.—Concurrently with the studies conducted with birds, an investigation was made to determine the effect of DDT on frogs and toads in the same wooded bottomland.

Open-topped cages—stocked with adults of green, pickerel, and bull frogs, with adult toads, and with frog and toad tadpoles—were prepared and placed before the DDT was applied. These cages were inspected daily for a 9-day period after the spraying. None of the animals was affected.

A second study was made in a series of 20- by 50-foot artificial ponds in which adults and tadpoles of several species of toads and frogs were living. Two ponds were treated with oil only; 2, with an oil solution containing DDT at the rate of 1-pound an acre; and 2, with a 5-pound an acre oil solution of DDT. These applications of DDT were made early in April with a hand-operated compressed-air sprayer. One of each pair of ponds was shallow; the other, deeper. Several untreated ponds were included in the observations. The ponds were sampled with dip nets twice before spraying and several times thereafter.

In the deeper of the two ponds treated with 1 pound of DDT an acre, no dead or sick animals were found; but in the shallow pond (5 inches deep at the center) several frogs and large frog-tadpoles and a young water snake were killed. These deaths and those of several frogs and large frog-tadpoles in both ponds treated at the rate of 5 pounds an acre, obviously were

caused by DDT; some tadpoles and frogs remained alive in all the treated ponds.

Fishes.—The 117-acre tract sprayed with an oil solution of DDT at the rate of 2 pounds an acre on June 5 included 0.9 of a mile of the Patuxent River, usually a muddy stream with a flow of about 130 cubic feet a second.

Nine and one-half hours after the spraying 95 dead fish were removed from a net stretched across the stream at the lower end of the sprayed section. Of 20 species seined or observed in the river, those killed in largest numbers were fallfish, common shiner, bluegill sunfish, eastern madtom, and silverling minnow. Fish drifted into the stop net for 4 days after the spraying of the river, but the greatest losses occurred within the first 48 hours. Johnny darters and rosy-sided dace were abundant in the seine hauls, but no dead were found.

Bluegill sunfish, yellow perch, and red-bellied sunfish were placed in six live-boxes in the river: one above, four within, and one placed 1.5 miles below the sprayed tract. Losses among the bluegills within the sprayed tract were heavy; the survival in each box was less than a third. Losses among the red-bellied sunfish were low, and the yellow perch were unaffected.

It is believed that spray drifting about 150 feet from the sprayed area to a small gravel-pit pond, killed all the golden shiners and pumpkin-seed sunfish in it. Red-bellied sunfish, yellow perch, and about one-third of the bluegills confined in a live-box in the same pond, survived. Mortality began later and lasted longer in the pond than in the river.

On May 8, each of eight shallow, 20 by 50-foot, soft-water ponds at the Patuxent Research Refuge was stocked with 30 large fingerling bluegill sunfish, 15 red-bellied sunfish, 14 yellow perch, and 3 adult white crappies. On May 9 three of the ponds were sprayed with 0.1 pound, 2 ponds with 0.5 pound, and 2 ponds with 1.0 pound of DDT in oil to the acre. An eighth pond was left unsprayed as a control.

The ponds were inspected at frequent intervals after the application. The control pond, one pond treated with 0.1 pound an acre, and one pond treated with 1 pound an acre of DDT, were drained for an accurate determination of the mortality.

At the rate of 1 pound to the acre, one drained pond had an 80-per cent loss in bluegill sunfish, 93-per cent loss in red-bellied sunfish, and 78-per cent loss in yellow perch. In ponds sprayed with 0.5 pound an acre there was also serious mortality. In one drained pond that had been sprayed with 0.1 pound to the acre, there was a loss of 43 per cent among all species.

LACKAWANNA COUNTY, PA.—A breeding-bird census similar to that at the Patuxent Refuge was taken on three 40-acre areas of forest land near Scranton, Pennsylvania, between May 1 and June 27, 1945.

Between May 24 and June 1 the experimental control of gypsy-moth larvae was begun by the application (by airplane) of an oil spray of DDT at the rate of 5 pounds to the acre on a 600-acre tract enclosing the first of these three bird-censused areas. The gypsy moth and other tree-feeding caterpillars were eliminated and many other insects were affected within a few hours. Some species were apparently unaffected. A hive of bees placed in the tract before it was sprayed came through in good condition. Several groups of insects that were reduced by DDT had again attained their normal numbers within 3 months.

Within 48 hours after the DDT was applied, five birds showing symptoms of DDT poisoning were found; all died. In addition, two other sick birds were found and 2 nests were abandoned. Species killed included red-eyed vireo, black and white warbler, ovenbird, redstart, and scarlet tanager. Within 48 hours after the application of DDT to the final portion of the area on June 1, the population of living birds (which had been 1.6 pairs to the acre before spraying) was much reduced. On June 13 the area contained only 0.5 birds an acre. The most commonly noted species were ovenbird and red-eyed vireo.

On June 9 an oil spray at the rate of 1 pound to the acre was applied by airplane to a 350-acre tract enclosing the second 40-acre bird-censused area. A nearly complete kill of gypsy-moth larvae and a conspicuous reduction in the general insect population were effected, but at no time were insects scarce. Most groups apparently recovered within a month.

The third area remained untreated as a control for the second.

Before spraying, the population of all

birds in these areas was 2.7 pairs an acre. The commonest species were ovenbird, red-eyed vireo, Canada warbler, magnolia warbler, northern water-thrush, and redstart. After spraying, the population was reduced to 2.6 pairs to the acre in the sprayed area and 2.4 in the control area, owing, presumably, to completion of nesting or to destruction by predators.

Fishes.—On August 9 a 3-mile section of Ash Creek, near Clifton, Pennsylvania, was sprayed by airplane with an oil solution of DDT, applied at the rate of 1 pound an acre as the plane followed the course of the stream. Analysis of filter papers placed at scattered points showed that an average of only 0.25 pound an acre of DDT actually reached the stream. Measurement of the drift of insects 2 hours after the DDT was applied, showed them passing downstream at the approximate rate of 60,000 an hour at the surface and 15,000 an hour at the bottom. Nine and one-half hours after spraying, the rate at the surface had dropped to 30,000, that at the bottom to 11,000. At the same time the natural drift of insects in Silver Creek (the control stream) was 704 an hour at the surface and 469 at the bottom.

A census taken before spraying indicated a total brook-trout population of 2100 in the sprayed section. There were also many common suckers, common shiners, black-nosed dace, fallfish, and golden shiners, particularly in the lower mile.

Weirs were located at four places in the stream to intercept dead or dying fish, and two live boxes were placed above each weir. In one of each pair of live boxes were placed 30 brook trout, and in the other a miscellaneous assortment of cold-water species. Control live boxes were placed in nearby Silver Creek, where conditions were nearly identical with those in Ash Creek.

Poisoned fish began drifting into the weirs 12 hours after spraying. Sixty-nine per cent of all observed fish losses occurred within 34 hours after spraying.

The warmer-water fishes—common shiners, common suckers, and golden shiners—were affected first, most of their mortality occurring within 2 days after spraying. It was estimated that less than half of them were killed.

Brook and brown trout were more slowly affected; their losses, as well as the loss of common suckers, lasted for a week. Sampling of the native brook-trout population before and after spraying indicated that only about 1.3 per cent of the brook-trout population (27 fish) were killed.

In the live boxes stocked with brook trout, the greatest loss was four fish, at the weir farthest downstream. In live boxes stocked with miscellaneous cold-water fishes—including sculpins, black-nosed dace, creek chubs, pearl minnows, top minnows, and common suckers—only 4 fish were killed out of a total of 203.

BLACK STURGEON LAKE AREA, ONTARIO.—During May and June 1945, the Department of Agriculture of Canada had 100 square miles of spruce-fir forest sprayed with 1 pound of DDT an acre to control spruce budworm. Observations indicated that 50 to 60 per cent of the budworm larvae were killed.

Bird studies of an intensive type were made on four plots of 25 acres each. Three of these four plots were sprayed. Populations ranged from 2.0 to 3.6 pairs of birds to the acre in the sprayed areas, and 4.4 pairs in the check area. Four birds affected with DDT jitters were found. It was believed, however, that no *measurable* changes had resulted either in the adult bird populations or in the several nests under observation.

SAVANNA ORDNANCE DEPOT, CARROLL COUNTY, ILLINOIS.—At 30-day intervals between August 5 and October 6, 1945, the Sixth Service Command sprayed 4000 acres (flood-plain area covered with mixed old-age hardwoods, a large island, and typical open-water area) to control mosquitoes. Applications of DDT (5 per cent solution in No. 2 fuel oil) ranged from 0.2 pound an acre to 0.5 pound on different areas. Observations on populations of birds, mammals, reptiles, amphibians, fish, and crustacea, were made before and after each spraying.

Mosquitoes were readily controlled with this solution of DDT when applied at 0.2 to 0.5 pound to the acre.

Bird nesting populations were little affected: few nests in this Upper Mississippi area were occupied after August 1. No direct effects on birds were noted, but swallows left the area to feed on land adjacent to the sprayed area.

Toothed herring and several species of shiners and dace were killed by the ap-

plication of 0.5 pound of DDT to the acre in agitated waters.

Most of the crayfish on the area were readily killed by 0.5 pound of DDT to the acre.

Raccoons that fed upon the crayfish showed no evidence of being affected. Other vertebrates apparently were unharmed.

ISLAND BEACH, OCEAN COUNTY, NEW JERSEY.—To eliminate mosquitoes, the southern 5 miles of Island Beach—including the shallow shore waters in Barnegat Bay—were sprayed by airplane on July 11 with an estimated 0.5 pound of DDT to the acre. Partial control was achieved.

On July 8, previous to spraying, large numbers of gulls, terns, herons, shorebirds, barn swallows, purple martins, redwings, and other song birds were observed. No direct effects on the birds were noted after the spraying, but most swallows and other insectivorous species left the area and remained away the rest of the summer. No sick or dead birds were found.

Blue crabs, plentiful along the bay shore before the spraying, moved out of the sprayed shore waters after the spraying but were abundant in unsprayed areas. No dead crabs were found 3 days after the spraying. By July 18 reports were received of the death of many blue crabs that had reappeared in the sprayed area; on July 21, 150 dead or dying crabs were counted on a 200-yard stretch, though crabs in adjacent unsprayed waters were healthy. On the latter date many active fiddler crabs and ground-inhabiting insects were in evidence and no dead birds were observed.

Along 5 miles of the shore on Barnegat Bay there were an estimated 100,000 small dead fishes (menhaden, mullet, and killifish) upon which terns and gulls were busily feeding.

OTHER FIELD OBSERVATIONS.—DDT was used on an experimental basis for insect control in several other localities, but on these the Fish and Wildlife Service personnel involved could not make detailed wildlife population studies. Careful qualitative observations were made, however, and in some of the localities damage by DDT was noted.

In Clatsop County, Oregon, an experimental spraying for the control of the hemlock looper was begun in early June and continued for several weeks. About 3000 acres were covered, mostly with less than 1 pound of DDT an acre. Partial control of the looper was effected. A large percentage of the crayfish in the Necanicum River (which crossed the tract) were killed. These crustacea remained healthy in a nearby unsprayed stream. Vertebrates apparently were unaffected.

At Fort Knox, Kentucky, more than 2500 acres were sprayed in early September with 0.4 pound of DDT to the acre for the control of malarial mosquitoes. Most of the mosquitoes and many other insects were killed. In one bottomland pond that probably received a dosage larger than that applied generally, a large proportion of the fish were killed: more than 100 dead and dying shiners and sunfish were found. Other vertebrates apparently were unharmed.

Part of Wallops Island, Virginia, was sprayed with an unreported amount of DDT in late August. Mosquitoes and greenhead flies were temporarily eliminated. Initial mortality was very high among blue and fiddler crabs in ponds and small streams and among fishes in the ponds, but on the third day no further effect was observed.

At Blowing Rock, North Carolina, a 217-acre tract comprising homesites, fields, and a golf course, was treated in late May and June to eradicate the Japanese beetle. DDT was applied in a dust at the rate of 25 pounds an acre. Beetles were reduced to one-third of their 1944 population. Entomologists and townspeople made observations on wildlife, reporting 30 sick or dead birds and 11 abandoned nests on five homesites and 12 sick or dead birds and 3 abandoned nests on two properties in woods adjacent to the treated tract. Typical DDT symptoms were observed in the affected birds, all of which were noted within 3 days after the dusting.

At localities in Maryland, Nebraska, Colorado, Wisconsin, and Ontario, DDT in an oil solution was applied at rates reported to range from 0.2 pound to 5 pounds an acre. Wildlife was affected only slightly, even at the highest rate. In Utah a field of alfalfa was treated with 1.5 pounds of DDT an acre in the form of a dust, with no apparent effect on birds.

LABORATORY STUDIES, Mammals.—During the spring of 1945 tests of DDT

toxicity were made on wild-trapped field mice. With a basal diet of corn, wheat, and oatmeal finely powdered, DDT was intimately combined in the following proportions, by weight: 0.40 per cent, 0.20 per cent, 0.10 per cent, 0.04 per cent, 0.02 per cent, and 0.01 per cent—one diet lacking DDT altogether. The mixtures were fed to groups of five animals each for a period of 30 days. Weight changes in the animals and amounts of food consumed, were recorded in the middle and at the end of the feeding period.

In the control group and in each of the groups receiving 0.01 to 0.10 per cent of DDT, there was no apparent toxic effect. In the group receiving 0.20 per cent of DDT in the diet, one mouse died soon after the initial exposure, and a second mouse died 2 days before the termination of the experiment. The presence of the drug in the diet apparently did not influence the amount of food consumed.

In all five of the mice that received 0.40 per cent of DDT, violent tremors were observed at the beginning of the third day after the first exposure. Before the end of the third day, two of these mice had died. Another animal died on the seventh day, and the fourth on the ninth. The last mouse lived until the twenty-first day, although decided tremors were evident throughout.

A similar series of tests made on wild-trapped white-footed mice showed them to be much less susceptible to DDT poisoning.

In the late winter of 1945, 10 field mice were placed in each of two cages and provided with food, water, and grass shelter to last a 30-day period. On the fourth day the entire habitat in one cage was sprayed by hand with a solution of DDT in oil at the rate of 5 pounds to the acre; the same oil mixture without DDT was sprayed over the entire habitat in the other cage. Fresh water was placed in each cage after the spraying. Seventeen days later DDT-sprayed oats were placed in the first cage, oil-sprayed oats in the second. At the end of 30 days there had been no evidence of toxicity from the use of either DDT or the oil alone.

Four cottontail rabbits were used in each of two tests of DDT toxicity, made in the spring of 1945. Crystalline DDT in the diet at the rate of 0.20 per cent produced tremors in one animal on the eleventh day, followed by complete recovery. All four animals fed with DDT at the rate of 0.40 per cent showed tremors; three of them showed tremors on the third day. Two animals died, one on the fifteenth day and one on the twentieth.

In another series of toxicity tests with cottontails, crystalline DDT was administered by means of a stomach tube in six dose levels ranging from 500 milligrams to 2500 milligrams per kilogram of body weight. No symptoms of poisoning were produced at levels below 1500 milligrams. One of three rabbits at the 1500-milligram level showed marked tremors on the second day, followed by complete recovery. The others and all at the lower dosages remained normal. Two of the four animals on the 2000-milligram dosage died on the third and thirteenth days, respectively. Two of the three animals on the 2500-milligram dosage died on the seventh and twelfth days.

Birds.—DDT toxicity in bobwhite quail was tested in the spring of 1944 through the use of series of 10 each of 5-week-old birds fed a mash diet containing DDT at percentages ranging from 0.40 to 0.005 during a 63-day period. Above 0.05 per cent, all the birds died. A 50 per cent loss occurred when DDT was fed at a level of 0.025 per cent of the diet, and there were some losses at the lowest level used. Daily food consumption for the entire period averaged 12 grams to the bird.

Toxicity was determined in adult bobwhite quail through the administration of single oral doses of DDT, either in crystalline form, in gelatin capsules, or in a vegetable oil solution. Dosages of the crystalline drug ranged from 50 milligrams per kilogram of body weight to 1000 milligrams per kilogram of body weight. Six birds were used for each test. Dosages of the oil solution ranged from 40 to 1000 milligrams per kilogram of body weight. The birds were starved for 24 hours and their weights taken for computation of the dose; they were then dosed and returned to regular feed.

Dosages of 200 milligrams per kilogram of body weight were required to cause a significant percentage of deaths. Mortality increased with larger doses, but there were survivals even at 1000 milligrams.

Owing to higher rate of absorption, DDT was much more toxic in vegetable oil solution than in crystalline form. Symptoms characteristic of DDT poisoning in other species—excessive nervousness, loss of appetite, tremors, muscular twitching, and persistent rigidity of the leg muscles, the last continuing through death—were observed in many of the birds. At the 75-milligram level, five of the six birds died; at 60 milligrams per kilogram of body weight, the DDT was fatal to four of the six birds dosed; at 50 milligrams only one of six died. Survivors in each of these groups returned to normal.

Amphibians.—In mid-March 1945, a number of wood-frog egg masses were collected from bottomland ponds along the Patuxent River. The eggs began hatching at once, and the tadpoles in groups of 100 (more than 2000 altogether) were placed in aquarium jars. Some of the jars were kept as controls and were not disturbed in any way; some jars were treated with oil only; and some were treated with DDT at the rate of 5 pounds an acre. The experiment resulted in the killing within 3 to 5 days of all tadpoles treated with DDT. Those kept as controls or treated with oil only, remained alive and healthy.

Fishes.—At the Leetown Fishery Station, West Virginia, four connected raceways, each 125 by 8 by 2 feet and supplied with 109 gallons of hard spring water per minute, were stocked in mid-August with 100 brook trout, 100 rainbow trout, and 100 bluegill sunfish each. These raceways were sprayed with an oil solution of DDT at the rate of 1 pound an acre. The spray was noticeable on their surfaces for 4 hours. Brook trout and rainbow trout, 5 to 7 inches in length, were unaffected; but 4 to 12 per cent of the 3.5-inch bluegill sunfish were killed. All losses of fish occurred within 5 days after the DDT was applied.

An experiment conducted late in October involved the stocking of each of 12 small, hard-water ponds with 50 bluegills (averaging about 3.5-inches in length) and 50 largemouth bass (averaging about 5 inches). DDT was applied in three different forms to three ponds each; three ponds were maintained as controls. On the nine ponds treated, DDT was applied as an oil solution, as an emulsion, and as a suspension—each at the rate of 1 pound of DDT to the acre.

A week after these applications the ponds were drained and the surviving fish counted. The suspension killed very few fish; the solution killed 50 to 60 per cent of the bluegills but very few bass; the emulsion killed all of both species.

Another experiment was conducted to determine whether fish could be killed by feeding on DDT-killed insects with no other DDT present. Each of three ponds was stocked with 25 adult and 25 fingerling bluegill sunfish. The fish in all three ponds were permitted to gorge for 3 days on flies, the flies of two ponds having been sprayed with a 12-per cent oil solution of DDT at the rate of 1 pound an acre, whereas the flies supplied to the fish in the third pond were untreated. No fish died.

SUMMARY.—1. Observations on the damage to wildlife caused by DDT used in insect control were made in 12 states and the Province of Ontario. Fair to successful insect control was effected.

2. The principal investigations were made on forest lands in Maryland and Pennsylvania, where forest tree pests were the objects of control.

3. Application of DDT was made chiefly by airplane as an oil spray. Spray concentrations ranged from 0.2 pound to 5 pounds an acre. The greatest amount used anywhere was 25 pounds an acre in the form of a dust.

4. The amount of DDT that actually reached the vegetation showed considerable local variation from the specified rate of application, owing to bad weather, lack of landmarks, defective spray apparatus, and different density of vegetation.

5. Pronounced mortality in wildlife resulted from the use of most of the higher concentrations of DDT; mortality was slight or not apparent in most of the lower. Invertebrates and cold-blooded vertebrates were more readily affected than were birds and mammals.

6. In the single trial involved, DDT was much more toxic in emulsion than when applied in oil or as a suspension.

RECOMMENDATIONS.— 1. *Don't Use DDT Unless You Must.* Undertake its use for the control of an insect pest only after weighing the value of such control against the harm that will be done to

beneficial forms of life. Wherever more than a small area is involved, consult county agricultural agents, State or Federal entomologists, wildlife and fishery biologists, and U. S. Public Health Service officials.

2. *Always Use Minimum Necessary Dosage.* Use less than 0.5 pound of DDT an acre in an oil solution to avoid damage to fishes, crabs, or crayfish; less than 2 pounds an acre to avoid damage to birds, amphibians, and mammals in forest areas. Do not use emulsions.

3. *Apply Carefully.* Use DDT only in calm, dry weather and only where it is needed. Wherever it is applied by airplane, provide careful plane-to-ground control to insure even coverage and to prevent local overdosage.

4. *Leave a Sanctuary.* In forest pest control, alternate treated and untreated strips in order to disturb wildlife as little as possible.

5. *Time the Application.* Making use of its residual effect, in the control of early appearing insect pests, apply DDT just before the emergence of leaves and the main spring migration of birds; for late-appearing pests, delay applications if possible past the nesting period of birds (to mid-August). Adjust crop applications and mosquito-control applications as much as possible to avoid the nesting period.

6. *Avoid Spraying Water.* Because of the sensitivity of fishes and crabs to DDT, do not apply directly to streams, lakes, and coastal bays.

7. *Watch What Happens.* Wherever DDT is used, make careful before-and-after observation on mammals, birds, fishes and other wildlife.—12-6-45.

DDT Emulsion Applied to Rice-Field Water to Control Mosquitoes

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During 1943 and the early spring of 1944 very promising field results were secured by members of the Orlando, Fla., laboratory of the Bureau of Entomology and Plant Quarantine with the use of DDT (1-trichloro-2,2-bis(*p*-chlorophenyl) ethane) as a larvicidal control of several species of *Anopheles* (Deonier *et al.* 1945) and *Psorophora* (Wisecup *et al.* 1945) mosquitoes. In order to assist the Surgeon General's Office in making recommendations on the use of this material in controlling mosquitoes in areas where irrigation is practiced, large-scale tests were conducted in the rice-growing area of east-central Arkansas during the period May 25 to September 4, 1944.

The previous work had shown that larvae of both *Anopheles* and *Psorophora* spp. were readily killed by very light dosages of DDT, and that a stable aqueous emulsion of DDT remained toxic for several weeks in static bodies of water. A material having these desirable characteristics presented for the first time a method of controlling mosquito larvae in flowing water other than by the use of large amounts of oil.

Rice culture as practiced in eastern Arkansas provides for an initial flooding of the recently sprouted rice early in June, followed by a thorough drying of the soil to control the rice weevil *Lissorhoptrus simplex* (Say), with a permanent reflooding in July. Drought, insufficient irrigation water, or too extensive an acreage of rice will often prevent the holding of an even depth of water on a field, with the result that frequent floodings may occur throughout the crop season. All water is drained from the mature rice early in September so that it can be harvested by machinery.

These floodings and dryings of the rice fields provide ideal situations for the development of large broods of *Psorophora* mosquitoes of the species *P. confinnis* (Lynch-Arr.), *P. discolor* (Coq.), and *P. ciliata*

[1] Entomologists, U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine, working under a transfer of funds, recommended by the Committee on Medical Research, from the Office of Scientific Research and Development.

[2] First lieutenant, Sanitary Corps, United States Army Air Forces, Stuttgart Army Air Field, Stuttgart, Ark. Additional equipment and untrained personnel were supplied by the Stuttgart Army Air Field, Eastern Flying Training Command, United States Army Air Forces; by the Corps of Engineers of the Eighth Service Command; the Office of the Chief of Engineers; and the Office of the Surgeon General, United States Army.

(F.). The periods of flooding may also be of sufficient length to permit large numbers of *Anopheles quadrimaculatus* Say to develop. These anophelines present a health hazard in the event of an outbreak of malaria, and the hordes of *Psorophora* are extremely annoying.

EXPERIMENTAL METHODS.—It had been determined that not more than 1 part of DDT to 1 million parts of water would be necessary for control of the indicated species of mosquitoes if thorough coverage could be secured. For these tests a basic concentrate was used which consisted of 20 per cent of DDT, 20 per cent of *Triton X-100* (an aralkyl polyether alcohol) as the emulsifying agent, and 60 per cent of xylene as the solvent. This concentrate was diluted with water to form emulsions ranging in concentration from 1 to 10 per cent of DDT before being applied to the flowing irrigation waters. Sixteen treatments were made on 10 fields. Some fields which had received an ineffective low concentration received a later treatment at a much higher concentration.

It was necessary to provide a more sensitive method of application than the use of conventional drip cans, since a constant supply of a very small quantity of material was required. Various valves were tested, as well as pumps and siphons, but all were found to need constant attention to prevent stoppage of flow. Primary dependence was finally placed on drip cans equipped with a metering valve (a fuel valve from an oil heating stove). In order to insure a constant rate of application, a 24-hour patrol of the treatment area was maintained so that the flow of emulsion could be adjusted as needed.

Water from both deep wells and impounded lakes is used for the irrigation of rice in the Arkansas area. The area in which these tests were conducted lay within 2 miles of the Stuttgart Army Air Field, and contained only diesel or electrically operated wells. These deep wells had capacities ranging from 450 to over 1000 gallons of water per minute. As a rule a single well was used to provide water for more than one field, the water for the outlying fields being conducted through open ditches for distances up to nearly a mile. For convenience of operation all applications of the DDT emulsion were made at the wells.

Weekly dipping records were obtained from all treated fields. At least 10 dips were made in each flooded contour. By working diagonally across each field from the point of entrance of the water into the field, it was possible to determine the straight-line distance over which a treatment was effective. Under the system of irrigation practiced in Arkansas the

Table 1.—Effect of adding DDT emulsions to the irrigation waters of 16 rice fields near Stuttgart, Ark.

CONCENTRATION OF DDT	ANTICIPATED DOSAGE OF DDT PER ACRE	SIZE OF FIELD	DISTANCE FROM POINT OF APPLICATION TO OUTLET INTO FIELD[1]	AREA CONTROLLED	TIME CONTROL PERSISTED
P.p.m.	*Pounds*	*Acres*	*Feet*	*Acres*	*Weeks*
0.035	0.07	30	0	3.7	0
.037	.06	110	0 and 1000	3.4	0
.047	.04	40	2500	0	0
.077	.17	70	0 and 1500	13.8	0
.175	.15	75	400	18.2	0
.22	.2	50	0 and 1000	34.4	0
.25	1.16	11	0	11.0	6
.385	.87	40	1500	19.5	0
.435	.6	30	0	30.0	3
.475	.87	40	1500	19.5	0
.55	.97	20	2500	20	2
.59	.98	30	0	30	5
.71	1.25	40	1500	40	0
.91	1.85	35	500 and 1000	35	7
1.02	1.43	70	0 and 1500	70	3
1.19	1.9	40	500 and 1500	40	6

[1] Several fields received water both direct from the well and by a canal to the lower portion.

water probably traveled back and forth across the field several times before reaching the lowest contour.

RESULTS.—Larval control obtained during the season when various concentrations of DDT were added to the irrigation water is shown in table 1. A treatment was considered to have become ineffective when any larvae could be found. Sometimes, however, fairly large numbers of recently hatched larvae could be found at this time but not until several weeks later would the DDT be sufficiently dissipated to allow the development of pupae and adults.

No reduction in larvae was ever noted beyond the first few contours when the concentration of DDT was less than 0.1 p.p.m. In the three tests with a concentration close to 0.2 p.p.m. initial breeding was entirely prevented only in the 11-acre field. Since the field was subjected to a long period of irrigation, a dosage equal to 1.16 pounds of DDT per acre was applied. There was no mosquito breeding in this field for 6 weeks, despite two refloodings with untreated water.

In the tests with concentrations near 0.4 p.p.m. the only field that showed complete control was again the smallest field (30 acres), which likewise had received its treatment direct from the well. It seems probable that the failure to obtain complete control over the entire area of the other two fields was due more to the fact that the water had traveled nearly a quarter of a mile in canals than to the difference in size of the fields.

The results in the fields treated with concentrations near 0.6 p.p.m. better illustrate the effects on control exerted by the size of the field and its distance from the point of application. At this concentration all fields received an average dosage of approximately 1 pound of DDT per acre, which was sufficient to give complete initial control. The differences in residual control were outstanding. In the 40-acre field, which received its water from a 1500-foot canal, breeding was resumed almost immediately; the 20-acre field, despite the fact that its water came through a 2500-foot canal, showed residual toxicity for 2 weeks, while the intermediate 30-acre field showed complete control for 5 weeks. The last field received its water direct from the well.

Size of field was even more important in effecting residual control in the fields treated at about 1 p.p.m., whereby approximately 1.5 pounds of DDT was applied per acre. The 70-acre field, with a dosage of 1.4 pounds per acre, retained its residual toxicity for only 3 weeks, whereas the 40- and 35-acre fields were free of larvae for 6 and 7 weeks, respectively. The last two fields had received somewhat larger dosages of DDT, but all the water had been conducted through canals.

DISCUSSION.—From these data it is evident that the degree of control in a field was affected (*a*) by the concentration of the DDT emulsion in the water, (*b*) by the dosage of DDT applied, (*c*) by the distance that the emulsion was carried in canals before it entered the field, and (*d*) by the size of the field. The basic concentrate containing 20 per cent of emulsifier tended to break and become dissipated when diluted in the deep-well irrigation waters of eastern Arkansas. It is probable that the highly mineralized hard water of this area tended to react unfavorably with the materials which were used for these tests.

Subsequent laboratory tests have demonstrated that intense aeration of water containing DDT emulsions and suspensions caused a decided loss of toxicity to mosquito larvae. This would indicate that the natural aeration which occurred in the swiftly flowing irrigation water was a primary cause of the decrease in toxicity of the DDT as the distance from the point of application was increased.

An entirely satisfactory method of applying the DDT emulsion was not developed during these tests. The very small amounts of material which were needed required minute outlets that could be subjected to fine adjustments; such fine openings invariably became clogged by crystals of DDT left by the evaporating xylene. The emulsion was deleterious to metal and plastic surfaces, and quickly ruined rubber hoses and gaskets. Conventional drip cans were unsuited for this type of application. Siphon drip cans gave a high degree of control, but were too sensitive to changes in the weather. Motor-driven fuel pumps likewise were inaccurate. Two types of chlorinators were found unsuitable, although the principle on which one operated might be used for this purpose. The metering valve gave the most satisfactory performance, but even

this apparatus required daily attention and adjustment.

Observations during the growing season showed no noticeable damage to the stands of rice due to the addition of the DDT emulsion to the irrigation waters. Counts of the rice grains per head at harvesttime indicated no decrease in yield of plump grains in treated fields. However, repreated applications may in time introduce soil residues that are deleterious to certain plants.

SUMMARY AND CONCLUSIONS.—Large-scale tests of the effectiveness of DDT in controlling *Anopheles* and *Psorophora* mosquito larvae were conducted during the period May 25 to September 4, 1944, in the rice fields near Stuttgart, Ark.

A basic concentrate consisting of 20 per cent of DDT, 60 per cent of xylene, and 20 per cent of *Triton X-100*, diluted with water to form emulsions of various strengths, was applied to flowing irrigation waters. Weekly surveys of 16 treatments involving over 730 acres of rice led to the following conclusions:

(1) The treatment is a feasible method of controlling mosquitoes in fields up to 70 acres in extent when the irrigation flow is about 1000 gallons per minute.

(2) Treatments should be applied at about 1 part of DDT per million parts of water to insure long-lasting results.

(3) The material should be applied close to the point where the water enters the field.

(4) It is imperative, however, that more satisfactory equipment be developed for the application of DDT to flowing water.

(5) The emulsions used in these tests did not damage the current crop of rice.—12-10-45.

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DDT Residual-Type Sprays as Affected by Light[1]

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Tests have been undertaken at Orlando, Fla., to determine the effect of exposure to ultraviolet light and sunlight on the residual properties of DDT (1-trichloro-2,2-bis(*p*-chlorophenyl)ethane). Particular attention has been given to deposits obtained from mixtures of kerosene and various auxiliary solvents, since it has been found necessary, sometimes, to use such solvents to prevent crystallization of DDT from kerosene at low temperatures.

ULTRAVIOLET LIGHT.—In these tests treatments were applied to 6- by 6-inch unpainted plywood boards, 3.5-inch glass petri dishes, and 4.5- by 4.5-inch flat glass plates. All the applications were adjusted so that the dosage was 200 mg. of DDT per square foot.

In these and subsequent tests the DDT solutions, emulsions, and suspensions were prepared on a weight-per-volume basis. For example, when auxiliary solvents were used, the solution was prepared by dissolving 5 gm. of DDT in 15 gm. of auxiliary solvent and diluting it with kerosene to a final volume of 100 ml.[2]

All treatments were made in duplicate. One lot was exposed 5.5 inches below an ultraviolet lamp, and the other lot remained unexposed as a check. The lamp utilized for this purpose operated on 110 volts A.C., and consisted of a 36-inch, *G.E.*, 30-watt tube beneath a silvered reflector. It is marketed as a germidical lamp, although no data are available relative to its spectral distribution. It is believed that most of the energy is emitted in the range 2500 to 2600 angstrom units, which is standard for most lamps of this type. The temperature at 55 inches was not materially higher than room temperature.

Exposed and unexposed residual de-

[1] This work was done under a transfer of funds, recommended by the Committee on Medical Research, from the Office of Scientific Research and Development to the Bureau of Entomology and Plant Quarantine.

[2] The residual spray issued by the Army contains 5 per cent of DDT, 15 per cent of *Velsicol AR-50*, and 80 per cent of kerosene, all by weight. The weight-per-volume basis was adopted in these tests for convenience in preparation. The DDT preparations for use in aqueous suspension were furnished by G. D. Patterson, of the National Defense Research Committee.

Table 1.—Effect of exposure to ultraviolet light on the time required for knock-down of houseflies in contact with surfaces sprayed with 5 per cent of DDT in various formulations. Treated surfaces exposed 132 hours.

Formulation	Minutes Required for Knock-Down after Contact With—							
	Treated Plywood Boards				Treated Petri Dishes			
	Tested Immediately After Exposure		Tested 72 Days After Exposure		Tested Immediately After Exposure		Tested 72 Days After Exposure	
	Unexposed	Exposed	Unexposed	Exposed	Unexposed	Exposed	Unexposed	Exposed
Kerosene solution	33	55	61	115	33	88	37	81
Kerosene solutions containing 15% of auxiliary solvent:								
Isophorone	29	57	72	104	33	93	25	37
APS-202 (refined high-boiling polymethylnaphthalenes)	31	115	98	101	28	178	29	132
Trichloroethylene	31	133	85	131	28	48	22	43
Velsicol AR-50 (chiefly mono- and dimethylnaphthalenes)	27	45	79	116	28	159	24	37
Solution in No. 2 fuel oil	31	51	72	145	26	240+	30	181
Aqueous suspension[1]	29	65	85	116	30	31	48	43

[1] Made with a wetting agent mechanically dispersed in water.

posits were tested against houseflies, *Musca domestica* L., by determining the time required to obtain 50 per cent and complete knock-down.[1] This was accomplished by placing 15 to 20 flies in a clean petri dish and inverting it over the treated surface. In parallel tests treated petri dishes were inverted over clean boards. Tests were conducted at 80° F. and were replicated 2 to 4 times. Preliminary tests had indicated that 48 hours' exposure to ultraviolet light materially reduced the effectiveness of the treatment.

Several series of tests were conducted with various periods of exposure. Two typical series of tests are presented in tables 1 and 2. In the first series (table 1) the treated surfaces were exposed to the lamp 6 days after spraying. A similar test, in which exposure to the lamp was made immediately after spraying, showed almost identical results. Although frequent determinations of knock-down time were made both during and after the period of exposure, in this and all other series of tests, only the end results are given as the intervening data are in line with the final records in all cases. Exposure to ultraviolet light reduced the effectiveness of all treatments, as shown by the longer time required for complete knock-down, both for the tests made immediately and those made 72 days after exposure. On the unexposed boards the knock-down time increased approximately 2 to 3 times when tested after the 72-day period, while the glass dishes showed practically no increase in knock-down in the same length of time.

In another series of tests (Table 2) the treated surfaces were exposed for 88 hours and tested 46 days after exposure. The results confirm those of table 1, in which the exposed treatments were less effective than the unexposed. The loss of effectiveness of DDT was greatest when high-boiling solvents (*APS-202*, benzyl benzoate, and motor oil) were used. In the unexposed petri dishes very short knock-down times were recorded with some solutions in the test made several days after treatment. These deposits were still liquid at the time of testing, and the toxic action of DDT is faster under such conditions. It has been found that, in general, high boiling auxiliary solvents decrease the knock-down time for several days after treatment if the surface remains unexposed to light. This is particularly true on an impervious surface such as glass.

Glass plates treated with DDT in kerosene solutions, which had been rendered comparatively ineffective by several days'

[1] In this paper the term "knock-down" is synonymous with "kill," since houseflies thus affected by contact with DDT never recover.

Table 2.—Effect of exposure to ultraviolet light on the time required for knock-down of houseflies *in contact with surfaces sprayed with kerosene solutions containing 5 per cent of DDT and 15 per cent* of various auxiliary solvents. Treated surfaces exposed 88 hours.

Auxiliary Solvent	Minutes Required for Knock-Down After Contact With—							
	Treated Plywood Boards				*Treated Petri Dishes*			
	Tested *Immediately* After Exposure		Tested *46 Days After* Exposure		Tested *Immediately* After Exposure		Tested *46 Days After* Exposure	
	Unexposed	Exposed	Unexposed	Exposed	Unexposed	Exposed	Unexposed	Exposed
No auxiliary solvent	22	36	27	58	29	64	34	75
Tetralin	20	36	28	25	34	38	57	79
APS-202	32	167	26	142	9[1]	180+	26	220+
Benzyl benzoate	27	155	31	149	7[1]	180+	40	180+
Motor oil (S.A.E. 10)	26	158	29	238	14[1]	180+	26	209
Velsicol AR-50	23	59	28	59	36	76	30	129

[1] Treatment still wet at time of test.

exposure to the lamp were treated with acetone. After the acetone had evaporated, the flies exposed to the plates were knocked down almost as fast as before the ultraviolet treatment. The acetone dissolved and thus redistributed the whole deposit. This would expose to the surface some of the undecomposed DDT which was below the surface layer when the deposit was exposed to light.

SUNLIGHT.—Two series of tests have been completed in which treated boards and glass plates were exposed to sunlight. In these tests, as before, unexposed treat-

Table 3.—Effect of exposure to sunlight on the time required for knock-down of houseflies in contact with surfaces sprayed with DDT or pyrethrum in various formulations. Treated surfaces exposed 90 hours.

Formulation	Minutes Required for Knock-Down After Contact With—							
	Treated Plywood Boards				Treated Glass Plates			
		Exposed				Exposed		
			In Florida				In Florida	
	Unexposed	In Texas	No Rain	Rain	Unexposed	In Texas	No Rain	Rain
DDT, 5%:								
In kerosene	23	21	32	33	26	42	39	51
Plus tetrahydronaphthalene 15% in kerosene	21	42	42	41	35	49	42	89
Plus *APS-202* 15% in kerosene	22	107	120	122	36	180+	61	180+
In No. 2 fuel oil	25	57	45	54	45	105	130	105
Aqueous emulsion made from concentrate containing DDT 25%, *Triton X-100* (a polyethylene glycol alkyl aryl ether) 10%, and xylene 65% (diluted 1:4)	31	37	37	66	23	22	23	27
Aqueous suspension[1]	18	39	38	64	12	12	16	21
Pyrethrum (1% pyrethrins):								
In kerosene	85	126	180+	180+	180+	180+	180+	180+
Plus "piperonyl cyclohexenone" (*No. 312*) 5% in kerosene	85	180+	180+	180+	13	180+	180+	180+
Plus "piperonyl cyclohexenone" (*No. 312*) 5%, *Triton X-100* 1%, acetone 4%, and talc 5%, in aqueous suspension	81	180+	180+	180+	12	180+	180+	180+

[1] Made with a wetting agent mechanically dispersed in water.

Table 4.—Effect of exposure to sunlight on the time required for knock-down of houseflies in contact with surfaces sprayed with 5 per cent of DDT in various formulations. Treated surfaces exposed 135 hours over an 18-day period.

Formulation	Boiling Point or Range (°C.) of Auxiliary Solvent (Approx.)	Minutes Required for Knock-Down After Contact With—			
		Treated Plywood Boards		Treated Glass Plates	
		Unexposed	Exposed[1]	Unexposed	Exposed
Kerosene solution	[2]	20	28	17	83
Kerosene solutions containing 15% of auxiliary solvents:					
Xylene	135–145	19	47	20	56
Cyclohexanone	157	16	24	23	89
Hi-Flash solvent	150–200	23	31	24	58
Solvesso No. 3 (aromatic petroleum fraction medium boiling range)	173–210	19	39	21	133
Isophorone	215	20	23	30	114
Velsicol AR-40 (chiefly monomethylnaphthalene)	220–243	18	27	35	121
Heavy solvent	160–270	18	27	29	89
Velsicol AR-50	236–269	30	34	31	118
PD-544-C (lower fraction of *S/V Culicide Oil B*)	200–277	16	26	25	180+
S/V Culicide Oil B (chiefly methyl polymethylnaphthalenes)	195–over 350	16	180+	31	180+
Velsicol NR-70 (chiefly tetramethylnaphthalene)	258–357	20	180+	36	180+
APS-202	288–377	20	180+	21	180+
Motor oil (S.A.E. 30)		20	53	14	180+
Solution in No. 2 fuel oil		20	43	26	180+
Aqueous emulsion[3]		28	35	24	33
Aqueous suspension[4]		24	93	16	16

[1] Average of 4 tests.
[2] The boiling range of crude kerosene is given as 150°–300° C., of refined kerosene as 188°–254°. No. 2 fuel oil boils approximately 90% within the range 227°–316°.
[3] Made from concentrate containing DDT 25%, *Triton X-100* 10%, and xylene 65% (diluted 1:4).
[4] Made from DDT with a wetting agent mechanically dispersed in water.

ments were used as checks. Exposure was made for 9 hours a day until the desired number of hours was attained. Boards and glasses were placed under cover at night, and additional exposure was made to compensate for periods of cloudiness. These samples were protected from rainfall. The effects of exposure were determined by the same methods as in the tests of exposure to ultraviolet light.

In the first series of tests conducted during April exposures were made at Orlando, Fla., and Menard, Tex. At Orlando, in addition to the regular set of exposures, a second set was allowed to remain out of doors continually and was therefore subjected to all weather conditions, including 1 inch of rain. The results in table 3 show that exposure affected all treatments, particularly those on glass plates. Loss of effectiveness of DDT was greatest when *APS-202* was used as the auxiliary solvent. The emulsion and the suspension were not seriously affected, especially on glass. Several pyrethrum sprays included in the series were almost completely inactivated. The rain probably removed some of the deposits.

Results of the second series of tests involving exposure to Florida sunlight are presented in table 4. As previous tests had indicated a possible relation between the volatility of the auxiliary solvent and the effect of exposure to sunlight, the solvents were chosen to give further indications on this point. The auxiliary solvents used are arranged in the table roughly in the order of their boiling ranges. The degree of decomposition by light, as judged by the time required for knock-down of houseflies, is somewhat in the order of the boiling range of the auxiliary solvent. Deposits from auxiliary solvents with boiling ranges near or below that of kerosene all showed practically no loss in effectiveness on wood; their effectiveness on glass was reduced, but to a much lesser extent than those with high-boiling solvents. Solvents

above the boiling range of kerosene gave deposits that showed marked reduction in effectiveness of DDT on both wood and glass surfaces. *PD-544-C*, which has a boiling range close to that of kerosene, showed no reduction on wood but definite reduction on glass. A more thorough study is needed of solvents with boiling ranges close to that of kerosene.

Deposits from the emulsion and the suspension again showed little or no loss in effectiveness of DDT.

These results all indicate that, as might be expected, DDT is more rapidly and completely decomposed in solution than as a solid deposit. Thus, comparatively dry deposits, such as those that form from the suspension and the emulsion, show least decomposition. Kerosene solutions made with rather volatile auxiliary solvents show less decomposition than those with nonvolatile solvents and evaporate to a dry deposit more quickly. The latter remain liquid for long periods and thus permit penetration of the light rays and resulting decomposition.

SUMMARY AND CONCLUSIONS.—Boards, petri dishes, and glass plates sprayed with DDT solutions, emulsions, and suspensions were exposed to ultraviolet light and to sunlight. Duplicate treatments were unexposed as checks. In the DDT solutions 15 per cent of various auxiliary solvents were included. Exposure to both ultraviolet light and sunlight reduced the effectiveness of the treatments in most cases, as shown by the time required to give a knock-down of houseflies, *Musca domestica* L. With several high-boiling auxiliary solvents, however, this reduction was particularly severe. It appears from these tests that in general, where decomposition by light may be a factor, auxiliary solvents used in conjunction with kerosene in DDT residual sprays should not only be good solvents for DDT but should be of the boiling range of kerosene or lower. Solvents of very low flash point should be avoided. Xylene emulsions an aqueous suspensions were less affected by light than solutions.—12-10-45.

DDT to Control Household and Stored Grain Insects[1]

J. J. DAVIS, *Purdue University Agricultural Experiment Station, Lafayette, Indiana*

My assignment was to include stored grain and household insects. However, as Doctor Knipling has discussed those insects of the home which are carriers of disease, and also bedbugs, it will be unnecessary for me to include flies, mosquitoes, fleas, and bedbugs in my discussion, although we do recognize these insects as major household pest problems, aside from their importance as disease carriers. Furthermore, for the most part, what I have to say will not refer so much to personal studies, but rather a brief résumé of published results.

STORED GRAIN INSECTS.—For the most part, the results which I will report, so far as seeds and stored grains are concerned, are the results of research by Dr. Cotton and his associates.

Briefly, the studies which have been reported indicate that seeds and grain are adequately protected against the common grain infesting insects by proper use of DDT; that its use with a carrier or diluent gives satisfactory distribution over the seed; that it may be combined with various seed disinfectants, such as *Spergon*, *Barbak*, *Ceresan* and others, for treatment against both insects and seed-borne diseases; that, so far as tested it has no harmful effect on germination; and that definite precautions should be made against the use of DDT, with our present knowledge, for the treatment of seeds or grains for use in animal feeds.

Becoming more specific, we find that in laboratory tests, a 3 per cent DDT dust mixed with wheat at the rate of 1 part to 10,000 parts by weight of grain, resulted in a 100 per cent mortality of adult red flour beetles, *Tribolium castaneum*, after confinement for 2 days; that wheat treated with DDT at the rate of 0.005 per cent, 0.025 per cent and 0.05 per cent by weight was effective after one year and that many dead adults of the lesser grain beetle and flour beetle, and dead larvae of the cadelle and Indian meal moth were found; that wheat, barley, oats, and

[1] A part of a Symposium presented at the Annual Meetings at Dallas, Texas, December 6, 1945 (other papers in the group not received).

sorghum seeds treated with 3 per cent DDT dust at varying rates from 0.05 to 0.1 per cent by weight, showed no infestation after a period of 8 months; that paper bags impregnated with a 10 per cent solution of DDT in acetone prevented the lesser grain borer, *Rhizopertha dominica*, and the cadelle, *Tenebriodes mauritanicus*, from cutting through the bags and after a 2-months exposure to infestation.

DDT in oil, emulsions, or in wettable forms at the rate of 5 per cent, applied to walls and woodwork of warehouses, flour mills, and empty grain bins were effective in destroying stored grain insects and are recommended as residual sprays in such places and especially for clean-up operations in farmers' grain bins.

Briefly then, studies to date show that DDT is effective against the common pests of stored seeds, that the treatments have no harmful effect on seed germination and that the treatment should be used only on seeds and grains to be used for planting and not on grains which are to be used for feeding purposes. In general the recommendation based on present knowledge is one ounce of a 3 per cent mixture to 100 pounds or 1 to 1600. Diluents include pyrophyllite or similar materials although it has been suggested that magnesium oxide may be preferable because it has a repellent effect.

HOUSEHOLD INSECTS.—As I have already stated, my assignment does not include all household insects, since flies, mosquitoes, fleas and bedbugs were handled by Doctor Knipling.

Most of the published results on the use of DDT as a control for household pests have referred to laboratory tests. Therefore, I wish first to call to your attention an outstanding piece of research conducted between industry and entomology, where actual field conditions were employed. I refer to the cooperative experiments between the Bureau of Entomology and Plant Quarantine and the Research Committee, headed by J. Edwin Sameth, of the National Pest Control Association. During 1944 and 1945, when DDT was available to civilians for experimental purposes only, special arrangements were made with the Bureau to provide limited amounts of formulated DDT to selected pest control operators, who agreed to use the material for service jobs, according to a prearranged project outline and to accurately report results as used under normal service conditions. The results of this nation-wide study under commercial pest control conditions have been reported in several Service Letters of the National Pest Control Association, and the last report was contained in Service Letter 372 of this Association.

Cockroaches are perhaps the commonest pests of the home, with the exception of flies and mosquitoes. At any rate, commercial pest control operators have been almost unanimous in declaring roaches as their major service problem. Of the four common species found in buildings (American, Oriental, German, and Brown Banded) a 10-per cent DDT powder has given excellent control of the American and Oriental roaches, but the reports of its efficiency against German and Brown Banded roaches are conflicting, perhaps the majority of investigators reporting negative results. However, Captain Truman, entomologist in charge of the Fifth Service Command, has reported to us verbally that he obtained excellent results throughout his Service Command against the German roach. This may be accounted for by the fact that more frequent treatments were made than under normal conditions and observations referred to those made several weeks after applications were started. A DDT concentrate of 25 per cent has been reported effective against brown banded roaches if applied as a residual spray to places where this species commonly hides, as behind wall pictures, in radio and piano boxes, dresser drawers and the like. Also, it has been reported effective against German and American roaches when mixed with dog biscuit or mouse food at the rate of 1 to 100 although the roaches required up to 3 weeks to succumb.

Everything considered, sodium fluoride, with or without pyrethrum, is perhaps still superior to DDT, at least in the hands of the commercial operator. It should be noted that a single application of either the DDT powder or liquid seems to scatter an infestation over a premise and may cause, temporarily, some embarrassment to home owners. I found no records on the use of a combination of DDT and sodium fluoride or pyrethrum.

Silverfish and *firebrats* are among the more common household pests. Studies indicate that they may be effectively

controlled by treating the sources of infestation with 5 per cent DDT powder or spray.

MOTH-PROOFING.—Under the heading of moth-proofing we will consider both clothes moths and carpet beetles. The results of the N.P.C.A. cooperative experiments show that DDT will give protection if the fabric contains 2 per cent or more of DDT of the weight of the fabric. As it would be applied by the housewife it probably would be of little value. Doubtless the eulans, fluorine and arsenial compounds are equally valuable and perhaps no chemical has the good results obtainable by the clean-up of breeding places, dry cleaning (without the use of so-called moth-proofing chemicals) and proper storage. We should, however, call attention to the real value of a DDT liquid when applied to obscure breeding places of the carpet beetle, such as in piano and radio boxes, cold air ducts, cracks around baseboards, and similar places where lint accumulates and offers a hidden breeding place.

The value of aerosols for moth control has been the subject of some discussion and has been stressed in advertising. As a matter of fact, the use of these "bombs" in closets and similar closed containers does kill the adult clothes moths but has no effect on the destructive larvae feeding more or less hidden beneath the folds of the fabrics. Perhaps if used regularly and frequently it would in time destroy enough of the emerging adult moths to check an infestation.

Ants. For such species of ants as the pavement ant, the little black ant, the red ant, and the carpenter ant, DDT powder has given relief up to 2 weeks when used as a barrier material, while the liquid has given protection up to 4 weeks. However, from results to date, it cannot be considered as equal to prevailing methods, such as poisoned jelly, honey, sugar or syrup.

Dermestes lardarius, (et al.), the larder beetles, are rather common household pests, especially in apartments with incinerators. They breed abundantly around incinerators where care has not been taken to burn all refuse. Of course, the proper procedure is to eliminate unburned refuse, but nevertheless it is worthy of notice that a 1 per cent kerosene spray of DDT will kill these beetles and their larvae when applied direct to the insect and that the residual material from such a spray is effective but is slow acting, requiring several days.

Brown Dog Tick. This is a serious household pest in the northern states in houses. Of course, in the southern states it survives the winters out-of-doors and perhaps is an even more severe problem. DDT liquid or powder has proved superior to prevailing methods, the liquid being the better. It is possible to eradicate a severe tick infestation in a building by a single, properly applied application of a 10-per cent dust or 5-per cent liquid. Two weeks are required to secure desired results. At the same time, the dogs should be treated with the powder.

Bees in Walls. In Indiana many inquiries are received regarding honeybees hiving between walls, and the control in the past has been by use of calcium cyanide dust. We have been able to use DDT with good results, using a 20 per cent dust or a 5 or 10 per cent spray, injected into the entrance.

Wasps. Paper wasps are also the subjects of many inquiries, especially where they nest near doors and windows. A 5-per cent dust of DDT has proven very satisfactory and effective in every case where tested.

Termites. With the studies reported to date, DDT cannot be recommended for termite control although there are indications that it may be used in combinations with other materials to advantage.

Fleas, bedbugs, flies, and mosquitoes, which are major household pests have been reported elsewhere and as noted are effectively controlled by the use of DDT. However, I would like to make an additional comment regarding fleas. In Indiana we have many inquiries regarding fleas in lawns. These infestations, of course, have a source. Just to report an instance, I found the infestation in lawns originating under an open back porch where the family dog slept. A single treatment with a 5 per cent dust under and immediately surrounding the porch eliminated the lawn infestation.—12-30-45.

DDT to Control Hornflies and Gulf Coast Ticks on Range Cattle in Florida

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It is well known that residual deposits of DDT will kill hornflies, *Siphona irritans* (L), but the optimum concentration and form in sprays and dips, the best methods of application, and the duration of residual action under different conditions are matters of controversy. The experiments reported here were carried out in southern Florida to attempt to answer some of these problems.

The summer weather conditions in inland southern Florida subject any outdoor insecticide deposit to a very severe test, probably as severe as anywhere in the United States. Almost every afternoon a tropical downpour of rain can be expected, of short duration but extremely intense. The remainder of the day the sun shines very hot and continuously. The temperature almost always is over 85° during the day and often over 95°. Humidity is very high. These experiments were carried on from mid-July to mid-September 1945, when rainfall at Clewiston, Florida was as follows: July 15 to 31—7.94 inches; August—3.77 inches (August 1–11 was a dry spell, the whole 3.77 inches fell August 12–31); and September 1 to 16—9.50 inches. All this rain fell in downpours of short duration each day.

Cattle were treated by dips or sprays in Hendry County and Glades County, around Clewiston, La Belle, and Moore Haven. Work was done under conditions as close as possible to normal range practices in this area. Whole herds of cattle were sprayed or dipped and returned immediately to their grazing lands. Counts of fly populations were taken by driving or riding out through the herds and examining, wherever possible, at least 25 head at close range, then calculating an average number of hornflies per head. It was impossible to make counts at definite regular intervals, but counts were taken more often than once a week. In all cases before spraying, cattle were heavily infested, at least 500 flies per head in the lightest infestations—the usual infestation being several thousand per head.

Six different methods of spraying cattle were tried out as follows:

A. Slow complete spraying of whole body as the cattle were held in a chute, using 2 nozzles off a power spray rig, spraying from both sides of the chute. Nearly a gallon of spray per head was necessary.

B. Incomplete spraying as the cattle were held in a chute, covering mainly the head, shoulders and back. Same equipment used as in A. An average of 1 quart per head was necessary.

C. Incomplete spraying as the cattle ran through a chute, covering mainly the head, shoulders, and back. Same equipment used as in A. Only 1 to 2 pints per head was necessary.

D. Spraying heads, shoulders, and backs only as the cattle milled around in a small pen, using 2 nozzles from a power spray rig, operators standing on fences on each side of the pen. One quart or less per head was necessary.

E. Spraying cattle all over as they ran out of a pen or chute. Spray directed mainly at the back, sides, and belly, using 2 nozzles from a power spray rig, operators standing on both sides of the exit gate. Less than 1 quart per head was necessary.

F. Fast, complete, but light spraying as the cattle ran through a bank of nozzles arranged around the inside of a chute. Seven nozzles with extra large discs operating at 150 to 200 pounds pressure were used, arranged so that 4 sprayed the sides, two the belly, and one the head and back. One quart or less per head was used.

The results of the whole series of tests are given in tables 1, 2, and 3. These are average summary tables of the data from treating 8402 head in 36 herds. In interpreting the data, it is considered that a zero, or less than 1 fly per head, average means the deposit was still active. Where cattle averaged one or more flies per head the deposits were no longer killing flies, even though no considerable build-up of flies occurred during the following several

Table 1.—Spraying cattle for hornfly control using DDT emulsions;[2] southern Florida, 1945.

Per Cent DDT	Spray Method	No. of Cattle	No. of Herds	Gals. Per Head	Rainfall	Average Number of Flies per Head During Following Intervals (in Days) after Spraying 4–6	7–9	10–13	14–20	21+	
0.125	A	60	2	0.8–1	Heavy	3	47	30	62	75	(23 days)
0.25	B	40	2	0.25–0.7	Heavy	2	33		75		
0.5	F	500	1	0.25	Extremely heavy	2	30		10		
0.5	D	80	2	0.25	Light	0	2	17			
1.0[1]	F	1300	1	0.17	Moderate	5	25	35		100	(21 days)
1.5	F	900	2	0.25	Extremely heavy	0	4		5		
2.5	F	500	1	0.25	Moderate	0	<1	1	5		

[1] 1 per cent adhesive added, this may have rendered the DDT unavailable to flies.
[2] In all cases Geigy *Neocid A 25* or *Gesarol A 20* emulsion was used.

weeks. No rapid build-up occurs in the cases of higher concentrations as flies have been killed off within the range area and build-up depends on slow migration into the area. Small differences in the fly population averages are of no significance as it is impossible to count hornflies accurately on cattle on the range. The cattle are constantly moving, cannot be approached too closely, and often only one side can be counted. Besides, fly populations vary tremendously within a herd, some cows harboring no flies whereas bulls in close association may be grossly infested. In all cases, no hornflies appeared during the first 3 days after spraying; thus the data in the tables begin with 4 days after spraying.

It was immediately apparent that the severe conditions of southern Florida necessitated higher concentrations than used previously in other sections. Sprays at from 0.1 to 0.2 per cent gave deposits that effectively killed hornflies for less than a week. This same concentration in dry range country has given 10 days to 2 weeks control. It was necessary to raise the concentration of emulsions to 2.5 per cent DDT to get 10 days effective deposit. It was necessary to raise the concentration of suspensions only to 1 per cent to get 2 weeks effective deposits.

Suspensions at all concentrations gave longer lasting deposits than emulsions. The probable reasons are masking against sunlight by the suspension carrier, and washing off in rain by the high wetting agent content of emulsions.

Dips were more effective at a given concentration than spray suspensions. This is due probably to a larger amount of DDT on the animal from dips as cattle remove more than a gallon per head from a vat, and also complete body coverage, including the undersides of the body which are less affected by rain and sun than the backs. Nevertheless, none of the dips approached in effectiveness the higher concentrations of suspension sprays. Dipping is a very uneconomical method of treatment for hornfly control as at least 2000 gallons of water must be charged with DDT regardless of the number of cattle to be treated, and over a gallon per head is taken out of the vat, whereas spraying can be done with a quart or less per head, and no more water charged with DDT than is necessary to apply to

Table 2.—Spraying cattle for hornfly control using DDT wettable powder;[3] southern Florida 1945.

Per Cent DDT	Spray Method	No. of Cattle	No. of Herds	Gals. Per Head	Rainfall	Average No. of Flies Per Head During Following Intervals (in Days) after Spraying 4–6	7–9	10–13	14–20	21+	
0.125	A	120	2	0.8–1	Heavy	1	6	12	20		
0.2	A	90	1	1	Heavy	2		15	20		
0.25[1]	A	32	2	0.8	Heavy	0	12		20		
0.38[2]	A	600	1	0.4	Light	<1	<1	1	20		
0.5	D	105	2	0.25	None 4 days then moderate	0	0	4	10	45	(28 days)
0.75	E	350	4	0.2–0.25	Moderate	0	<1	2	3	9	(25 days)
1.0	E	140	2	0.2–0.25	Moderate	0	0	<1	2	10	(25 days)
1.0	F	640	1	0.17	Light for 10 days then moderate	0	0	0	2	10	(28 days)
1.5	F	250	1	0.25	Extremely heavy	0	<1		2		
1.5	C	800	2	0.1	Moderate	0	0		3	7	(21 days)
2.5	F	350	1	0.2	Light for 10 days then moderate	0	0	1	1	10	(26 days)

[1] On 6th day 8 untreated cattle mixed in with one herd.
[2] Moved to clean pasture after spraying.
[3] In all cases Geigy *Neocid Barn Spray* was used.

the cattle. Even low concentrations such as 0.25 per cent are expensive when large vats must be charged.

From the results of these tests it is considered that there is no advantage in using a spray suspension concentration above 1 per cent DDT. All concentrations of 1 per cent and over gave almost 2 weeks effective killing deposit, and insignificant populations for more than a month after spraying. Since the life cycle of the hornfly in hot weather requires less than 2 weeks it is evident that the above sprays will all practically eradicate hornflies from the area upon which too slow and requires too much material. Using nozzles arranged in the chute was an extremely fast, efficient, and labor-saving method. Only one man was required to do the spraying; he stood at the back of the spray rig and shut off the spray whenever the line of cattle moving through was interrupted. As an example of the rapidity possible, over 1300 head of Hereford cows were sprayed in less than 2 hours, and 350 Brahma cross bred steers in half an hour. By this method a considerable quantity of spray is applied to the undersides of the body where it is protected from weathering

Table 3.—Dipping cattle for hornfly control using DDT wettable powder; southern Florida 1945

Per Cent DDT	No. of Cattle	No. of Herds	Rainfall	Average No. of Flies per Head During Following Intervals (in Days) after Dipping[1]			
				7–9	10–13	14–20	21+
0.1	350	2	Extremely heavy	1	4	8	22 (28 days)
0.125	95	1	Moderate	1	4	25	
0.18[2]	900	1	Moderate	1	1	2	10 (23 days)
0.25	50	1	Moderate	1	5		40 (24 days)
0.25[3]	150	1	Extremely heavy	5	10	35	

[1] No observations until 7 days after dipping.
[2] Transferred to clean pasture after dipping.
[3] Eight days after dipping 25 head infested cattle were mixed in. Three days after dipping less than 1 fly per head was noted.
[4] In all cases Geigy *Neocid Barn Spray* was used.

treated cattle range, and the rate of reinfestation will depend upon rate of migration into the area and the size of the area. The much higher cost of 2.5 per cent DDT spray (44 pounds of 50 per cent wettable powder per 100 gallons for 2.5 per cent; only 17 pounds for 1 per cent) unduly increases the cost of treatment.

Rainfall had a definite effect on duration of residual action of the deposits. The first 2 weeks of August were relatively dry, and deposits were markedly longer-acting at that time. The effect of heavy rainfall is somewhat masked by the lowered rate of breeding under such conditions; it should be remembered that much of the range was under water in spells of extreme rainfall.

The method of spraying had no significant effect on the control obtained. The spraying was done with equipment available in the immediate areas, so that experiments could not be set up to evaluate methods accurately. Attempting to spray cattle thoroughly for fly control (Method A) is impractical. This method is much and sun, and also where mosquitoes attack in greatest numbers.

Spraying cattle as they mill around in a pen is also fast and effective but little spray is applied to areas other than the back so that flies biting other areas are not affected.

The effect on other biting flies could not be accurately determined. The habit of the hornfly of constantly associating with cattle renders it a useful index of length of residual action of deposits. The deposits would probably retain killing power for a similar length of time against mosquitoes. Mosquito (*Aëdes, Psorophora* sp. mostly) populations fluctuated greatly with the weather; nevertheless, the sprayings caused a separate noticeable decline in population on the ranges where large numbers of cattle were sprayed. Adults, though were constantly emerging so that the sprayings never completely controlled them. There was no noticeable effect on tabanid populations.

Gulf Coast Tick.—The Gulf Coast tick *Amblyomma maculatum* Koch, is a serious pest in southern Florida for at least

2 months during the late summer. In themselves, the ticks are unimportant, but these ticks are the major cause of wounds in which screwworms develop during their active season. Cattlemen commonly round up their herds several times in late summer and grease the ears to control ticks.

DDT was tested for tick control by incorporating it in a grease for hand treatment and as an emulsion plus an adhesive for spraying the ears. Both methods successfully prevented screwworm ear cases for more than a month.

The sprays used contained 4 per cent and 5 per cent DDT, applied by a 3 gallon compressed air sprayer. No ear screwworm cases developed from tick wounds for over 4 weeks on treated cattle whereas untreated cattle in the same area averaged 5 to 10 per cent infested.

The greases used contained 8 per cent DDT in gear compound and roller track lubricant plus 26 per cent sulfur. Where there had been 30 ear cases in 500 cattle in one week before application, there was only one ear case in 6 weeks following treatment in these same cattle.

The grease treatment gave as good results as the spraying and is much more practical for cattlemen than spraying. It requires no special equipment and the DDT can be mixed into readily available materials.

SUMMARY.—Spraying and dipping of 8402 beef cattle in 36 herds in southern Florida for control of hornflies by DDT indicated the following:

1. The extreme summer weather conditions, particularly heavy daily downpours of rain, quickly render inactive, deposits from low concentration sprays.

2. Deposits from suspensions resist inactivation better than deposits from emulsions.

3. Deposits from sprays of 1 per cent or more DDT suspensions remain lethal to hornflies for almost 2 weeks, and will keep hornfly populations on whole herds at insignificant levels for over a month.

4. Deposits from sprays of 1.5 and 2.5 per cent DDT suspension remain active little if any longer than at 1 per cent and the much higher cost of 2.5 per cent renders its use very doubtful, at least under the conditions of these experiments.

5. For long lasting residual action from emulsions it appears that at least 2.5 per cent DDT is required in the spray.

6. Dipping is more effective at equal concentration than spraying, but requires so much more material that it is of doubtful practicability. Spraying with 1 per cent DDT is far cheaper than dipping in 0.25 per cent.

7. A very rapid effective method of spraying is to arrange many nozzles inside a chute so as to cover the whole body as the cattle run through the spray.

8. The treatment apparently reduced mosquito populations in some cases, but had little effect on tabanids.

9. Inclusion of DDT in adhesive sprays or greases applied to the ears of cattle will markedly reduce incidence of screwworm ear cases pre-disposed by Gulf Coast tick infestations.[1]—2-15-46.

[1] Prompt publication secured by payment of costs of printing.

DDT for the Control of the Horn Fly in Kansas

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During the summer of 1945 tests with DDT for the control of the horn fly were conducted in 16 counties in Kansas in cooperation with the Extension Department of the Kansas State College of Agriculture, the Office of the Livestock Sanitary Commissioner of Kansas, the Southwestern Regional Office of the National Live Stock Loss Prevention Board of Kansas City, Mo., and the U. S. Bureau of Entomology and Plant Quarantine. The objects of these tests were (1) to determine the duration of effectiveness of DDT sprays and dips against horn flies under practical field conditions, (2) to determine the value of DDT to the cattle owner for the control of horn flies, and (3) to familiarize livestock owners with the proper use of DDT for treating animals for control of flies and other external parasites. The DDT was obtained in the form of a water-dispersible powder and was diluted with

water to give a suspension containing 0.2 per cent of DDT for the sprays and 0.1 per cent of DDT for the dips.

This area includes all the principal cattle-grazing and -feeding areas in Kansas. Johnson and Bourbon Counties are located in the bluegrass and miscellaneous grasses area in the far-eastern part of the State; Riley, Wabaunsee, Morris, Chase, Greenwood, and Butler Counties are in the bluestem or flint hills section of eastern Kansas; Saline County, in central Kansas, and Barber, Comanche, and Kiowa Counties, in the southern part of the State, are in the mixed bluestem and short grasses area; and Finney, Logan, and Scott Counties, in western Kansas, and Smith County, in the far-northern part, are mostly or entirely in the short or buffalo and grama grasses region. Most of the 750,000 cattle that are annually imported during normal years for grazing and fattening are located in these areas.

In Kansas the horn fly is a serious pest throughout the state during June, July, August, and September. Each year this pest becomes so abundant and injurious to cattle that the feeding of animals in feed lots to prepare them for market was found to be unprofitable during this period and was discontinued years ago. By June of 1945, when the tests were begun, beef cattle carried an average of from 500 to 1500 flies per animal in different herds, and some of the aged bulls carried as many as 10,000 flies. The horn fly population on untreated animals reached its peak during the latter part of July and in August, when the average number of flies per animal was estimated to be as high as 3000 in some herds throughout the state, and bulls were observed on which the number of flies was estimated to be as high as 20,000. Infestations of horn flies as heavy as these are not peculiar to Kansas but are common throughout the southern and southwestern states. In the Gulf States heavy horn fly infestation on cattle usually extends for a period of 6 to 7 months each season.

The initial treatment of all herds was made by the representatives of the four cooperating agencies. The county agent also participated in this treatment, and directed the fly counts. As soon as he observed an abrupt increase of horn flies on the treated herds, he made arrangements with the owner of the herd for the next treatment. All treatments following the initial one were made by the three local cooperating agencies, together with the county agent and the herd owners. Wherever facilities for weighing the herds were available, all or part of each herd was weighed in order to determine the gains in weight during the test period.

Power sprayers equipped with 3- or 4-nozzle brooms and capable of maintaining a constant nozzle pressure of 400 to 500 pounds per square inch were used for applying the spray to the animals. The spray was applied to the upper half of the body and to the neck and head of each animal. Approximately 2 quarts of spray was applied to each adult animal and about 1 quart to each calf. The best results were obtained when the nozzles were held rather close to the animal to drive the spray through the coat of hair and to drench the skin thoroughly (Fig. 1).

In two herds only half the animals were sprayed. After treatment both the sprayed and the unsprayed animals were kept together in the same pasture, where they commingled daily. Since horn flies move freely from one animal to another one nearby, it was desirous to determine the results obtained by half-herd spraying. Two other herds, one of which contained over 1000 animals of all ages, were dipped in order to compare the results with those obtained from sprays.

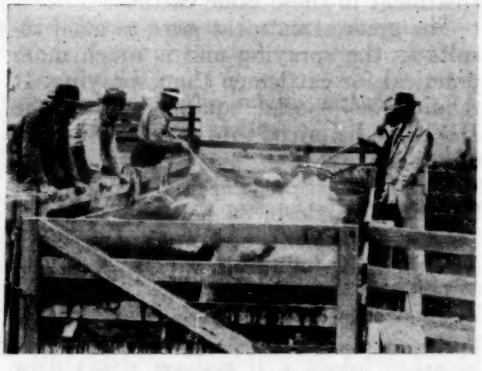

FIG. 1.—Spraying cattle with mist-nozzle brooms. Broom at left is held at correct height above animals, whereas broom at right is held too high for best results. Operators are standing on catwalks extending the full length of the pen, which is approximately 24 feet long by 12 feet wide. These facilities permit spraying 300 cattle per hour.

Barns and sheds were also treated with different concentrations of DDT suspensions and emulsions in order to determine their merits for the control of the stablefly, *Stomoxys calcitrans* (L.), and the housefly, *Musca domestica* L., both of which were abundant. All the tests were begun during the middle of June and were concluded by the first of October.

Table 1 shows the results of the tests with DDT suspension for whole-herd spraying and half-herd spraying.

The tests gave important information, not only on the effectiveness of DDT against horn flies, but on the amount of damage done by the horn fly to the cattle industry in Kansas. As shown in table 2, the treated cows and calves on ranches 1, 3, and 4 gained 42.2 to 51 pounds and 46.9 to 70 pounds more, respectively, per animal, than the untreated cows and calves. Although the test on ranch 2 ran for only 60 days, the 601 animals that were sprayed three times gained 18,030 pounds

Table 1.—Duration of effectiveness of 0.2 per cent DDT suspensions applied as a spray to beef cattle for the control of the horn fly.

APPLICATIONS	PORTION OF HERD TREATED	TOTAL NUMBER OF ANIMALS TREATED	NUMBER OF HERDS PROTECTED FOR INDICATED NUMBER OF DAYS										AVERAGE DAYS PROTECTED
			9	12	15	18	21	24	27	30	33	36	
First	All	3256	1	8	11	2							13.9
	Half	337		1	1								13.5
Second	All	3256		3	7	6	3	2	1				20.6
	Half	337					2						21.0
Third	All	3108				1	2		6	3	5	4	29.5
	Half	337					2						21.0
Fourth	All	444							1		1	1	32.0

Where all the animals in the herd were sprayed, the average duration of effectiveness increased with each treatment, but where only half were sprayed the duration of effectiveness was no greater after the third than after the second spraying. Although good results were obtained with half-herd treatment, the longer protection afforded by repeated whole-herd treatments was considered preferable because the cost for whole-herd treatments would be less than for a greater number of half-herd treatments.

Four dippings of 0.1-per cent DDT were effective for as long a time as were the four sprayings with 0.2-per cent DDT, the first application giving protection for 18 days, the second and third for 21 days, and the fourth for 36 days. Dipping, however, required approximately three times the amount of DDT needed for spraying, owing to the greater amount of material needed to charge a dipping vat.

The weight gains of some of the treated herds and similar untreated herds during the period of these tests are given in table 2.

more than the untreated animals. This gain in weight for the 900 gallons of spray containing approximately 15 pounds of technical DDT was 1202 pounds weight for each pound of DDT used. On ranch 1, where 4.25 pounds of technical DDT was used for the four sprayings, the application of each pound of DDT resulted in the production of 1285 additional pounds of beef; and on ranch 3, where the greatest gain was obtained, for each pound of DDT there was a gain of 2306 pounds. On ranch 4 the dip was used with 103 pounds of technical DDT for dipping 1017 animals four times. This yielded a return of only 430 pounds of beef for each pound of DDT used. The average weight gain for the cows on ranches 3, and 4 was 46 pounds, and for the calves, 59 pounds. On ranch 2 the average gain of the treated herd, which consisted of all classes and ages of animals from calves to aged bulls and cows, was 30 pounds per head over the animals in the check herd.

According to the estimates of the United States Department of Agricul-

Table 2.—Gains in weight of animals treated with DDT for the control of horn flies as compared with weight of untreated animals.

RANCH	PERIOD AND PLACE OF TEST	CLASS	TREATMENT	ANIMALS	AVERAGE WEIGHT AT BEGINNING	AVERAGE GAIN	GAIN RESULTING FROM TREATMENT
				Number	*Pounds*	*Pounds*	*Pounds*
1	May 2–Oct. 1 Barber Co.	Cows	4 sprays	55	1080.0	225.0	51.0
			None	16	972.0	174.0	
		Calves	4 sprays	45	150.0	320.0	59.0
			None	14	125.0	261.0	
2	May 8–Aug. 15 Kiowa Co.	Mixed	3 sprays	601	570.0	224.0	30.0
			None	50	567.0	194.0	
3	May 14–Sept. 24 Smith Co.	Cows	3 sprays	45	895.5	102.5	43.7
			None	41	868.2	58.8	
		Calves	3 sprays	27	160.0	266.0	70.0
			None	28	212.1	196.0	
4	June 15–Oct. 1 Saline Co.	Cows	Dipped 4 times	42	1110.0	105.5	42.2
			None	42	1022.0	63.3	
		Calves	Dipped 4 times	28	183.0	164.3	46.9
			None	36	236.1	117.4	

ture,[1] there were 2,866,000 beef cattle of all classes in Kansas on January 1, 1945. If the average gain of 30 pounds per animal, as shown in table 2, ranch 2, is applied as a yardstick, the loss of beef due to horn fly injury during 1945 would amount to 85,980,000 pounds, or a value of approximately $8,598,000. This estimate does not include the loss sustained on an estimated number of 1,171,000 dairy cattle in Kansas during 1945. Therefore, if horn flies were the sole factor and equally abundant throughout the state, the loss sustained in Kansas alone during 1945, as a result of horn fly injury, would be approximately $10,000,000.

Residual sprays applied to barns for the control of houseflies and stableflies showed that nine barns sprayed with a 5-per cent DDT emulsion were practically freed of these flies for 73 to 98 days. One barn, at the Kansas State College of Agriculture, sprayed with 2.5 per cent of DDT in suspension was practically free of flies for at least 90 days, whereas a long shed on the college grounds sprayed very heavily with 0.2-per cent DDT emulsion remained free of flies for only 2 weeks. Several other barns heavily sprayed with 0.2 per cent of DDT, either in suspension or in emulsion, remained free of flies for at least 3 weeks. Therefore, if the interiors of barns are thoroughly sprayed with 0.2 per cent of DDT at the same time that the cattle are sprayed for the control of horn flies, excellent control of stableflies and houseflies should be obtained as well.

It is estimated that as a direct result of these tests and demonstrations, in which about 40 herd owners cooperated, at least one million cattle will be treated with DDT for the control of horn flies in Kansas during 1946.

[1] U. S. Bur. Agr. Econ., Crop Reporting Board, Release of Feb. 16, 1945.

An Effective Method of Controlling Codling Moth in Oklahoma Orchards

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Many factors tend to alleviate or intensify the codling moth problem according to the location of any given orchard. Many of these factors are but imperfectly understood; there are others concerning which considerable information is available. One very important factor in the latter group is the length of the growing season. The longer the growing season, the greater the number of generations of codling moths that have time to develop and the shorter the growing season, the smaller the number of generations of moths. This factor alone probably accounts for there being but one generation of moths in the most northern parts of the apple belt; the number increasing to the south until at the southern edge, three full generations and a partial fourth regularly occur. Since the number of codling moths increases in geometric ratio with the number of generations, the problem is greatly intensified at the southern edge of the apple belt.

Numerous entomologists and orchardists have noted that dry, warm summers are in general favorable to codling moth development, and that such summers typically are accompanied by severe injury unless some other factor such as a crop failure the preceding year has reduced the moth populations. The climatic records of Oklahoma show that typically there is abundant moisture during the spring months but a deficiency during June, July, August and September, and that drouths 15 to 30 days in duration are very common. High temperatures and low humidity also are characteristics of this same period, with the result that the typical Oklahoma summer is of the type commonly considered most favorable for codling moth development.

It therefore seems likely that Oklahoma's location on the extreme southern edge of the apple belt, with its long growing season and its dry warm summers accounts for the severity of infestations of this pest regularly occurring within the state; under such circumstances and considering the difficulties encountered in control in areas less favorable to codling moth development, satisfactory control based on more intensive spray programs seemed unlikely, therefore, some other method was sought.

Of various plans considered, the most promising was reduction of the overwintering population by having orchards in which all apples mature and are harvested before the majority of the codling moth larvae enter hibernation. Since numerous horticulturists in Oklahoma consider early apples more profitable than late apples, it appears that this plan if successful would fit well into a horticulture program.

This paper is a preliminary report on investigations conducted during the past three summers to determine whether or not such a method might be effective. The information obtained to date indicates not only that it would be effective, but also inexpensive and would be practical under Oklahoma market conditions. The proposed plan would be to plant apple orchards containing only trees from which the fruit may be harvested not later than the middle of August. The date of August 15 was selected for three reasons:

1. The data obtained in experiments reported later in this paper indicate by this date a very small proportion of larvae have entered hibernation.
2. After this date there was a very rapid rise in the percentage of larvae that hibernate rather than pupate.
3. This date is sufficiently late to permit the growing of a variety of apples (Summer Champion) that has made the best yield record of all the apple varieties grown in the experiment station orchard, while several days elapse before other really desirable varieties reach maturity.

REVIEW OF LITERATURE.—Numerous authors have noted that light injury from codling moths is experienced from 1 to 2 years following apple crop failures and have attributed this condition to the light carry over of moths following years when few apples were present on which the overwintering forms could develop. Aside from such statements, few papers

have been published having a direct bearing on this problem.

Bodenheimer & Naim (1929) in Palestine, Doinikov (1936) in Russia, and Nel (1942) in South Africa all have indicated that interplanting of early and late varieties increased moth populations and have suggested isolated plantings of one variety or of varieties having similar dates of maturity.

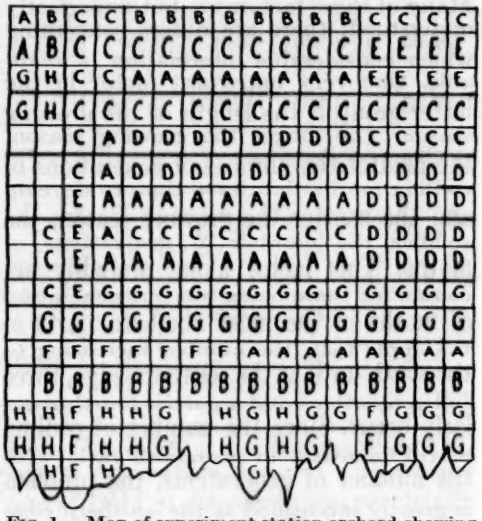
Isely (1943) obtained data under conditions much more nearly approximating those in Oklahoma. By making infestation counts at harvest or shortly before, he observed that "orchards which include only the variety Transparent (ripening in late June) and which are separated from later varieties by a distance of at least one-fourth mile, have been found to be practically worm free at harvest even though all cover sprays for codling moth control were omitted." His data also clearly indicate that (1) where blocks of apples of similar ripening dates were isolated, the earlier the fruit matured the less the injury; (2) that the interplanting of early and late varieties increased the injury to all varieties; and (3) that in varieties ripening the last of August and early September, the codling moth problem was much less severe when they were isolated from later varieties.

EXPERIMENTAL PROCEDURE AND CONDITIONS.—The primary objective in setting up these experiments was to obtain information concerning (a) the comparative numbers of codling moth larvae entering hibernation on apple varieties of different ripening dates, and (b) accurate information as to the time of year the moths entered hibernation.

Most of the data were taken in the experiment station orchard located near Perkins, Oklahoma, nine miles south of Stillwater. This orchard is well adapted for the purpose in that it contains apple varieties ripening at all periods from late June until early October. The trees are from 11 to 14 years of age and were grouped according to their date of ripening as follows:

Group	Date of Ripening
A	Before July 1
B	July 1–15
C	July 16–31
D	August 1–15
E	August 16–31
F	September 1–15
G	September 16–30
H	After September 30

Figure 1 shows the locations of the trees. In general the early varieties were isolated from the late varieties, though some early fall varieties were interplanted in this block and late fall varieties were nearby.


A B C C B B B B B B B B C C C C
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G H C C A A A A A A A A E E E E
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B B B B B B B B B B B B B B B B
H H F H H G H G H G G F G G G
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FIG. 1.—Map of experiment station orchard showing ripening date. (Key: A—Before June 30; B—July 1 to 15; C—July 16 to 31; D—August 1 to 14; E—August 16 to 31; F—September 1 to 15; G—September 16 to 30; H—October 1 and later.

Ten trees, bearing a good crop of apples, were selected each year from each group. In a few groups the number of trees bearing a good crop was less than ten, in which cases all trees available were used. Since the number of early fruiting varieties was small as compared to the number of late varieties, it was necessary to use a high proportion of the later varieties. The trunks and larger limbs of the trees were scraped to remove rough bark and when worms of the first brood were beginning to reach maturity, a burlap band was placed around the trunk of each tree. The larvae were collected from under these bands daily in 1943 and three times weekly in 1944 and 1945. The larvae from each group together with pupation sticks, were placed in a one-quart wide mouthed fruit jar and covered with a screen cut to fit the inside of the Kerr rings used to cover the jars. Larvae failing to enter the pupation sticks in the jar were placed in them by hand.

Table 1.—Total numbers and dates of collection of hibernating larvae from trees of different ripening dates in the experiment station orchard, Perkins, Oklahoma 1943, 1944 and 1945.

DATE OF RIPENING	AUG. 1–15	AUG. 16–31	SEPT. 1–15	SEPT. 16–30	AFTER SEPT. 30	TOTAL HIBERNATING POPULATION		
							Number	Cumulative Per cent
No. TREES	42	24	48	65	120			
Date Collected						Total by dates		
June 14	—	—	—	—	—	1	1	0.04
July 1–5	—	—	—	1	—	1	2	0.09
6–10	1	1	1	—	1	4	6	0.26
11–15	3	—	—	—	1	4	10	0.44
16–20	—	1	1	1	—	3	13	0.57
21–25	1	—	—	—	3	5	18	0.79
26–30	2	—	1	1	1	5	23	1.0
July 31–Aug. 4	4	1	2	2	3	12	35	1.5
5–9	—	—	5	3	6	14	49	2.2
10–14	—	6	10	8	11	35	84	3.7
15–19	—	4	12	8	8	32	116	5.1
20–24	—	15	17	49	21	102	218	9.6
25–29	—	3	37	62	91	193	411	18.1
Aug. 30–Sept. 3	—	—	8	101	164	273	684	30.2
4–8	—	—	11	46	123	180	864	38.1
9–13	—	—	2	59	137	198	1062	46.8
14–18	—	—	—	36	90	126	1188	52.4
19–23	—	—	—	33	117	150	1338	59.0
24–28	—	—	—	24	234	258	1596	70.4
Sept. 29–Oct. 3	—	—	—	4	120	124	1720	75.9
4–8	—	—	—	—	158	158	1878	82.8
9–13	—	—	—	—	61	61	1939	85.5
14–18	—	—	—	—	92	92	2031	89.6
19–23	—	—	—	—	57	57	2088	92.1
24–28	—	—	—	—	131	131	2219	97.9
Oct. 29–Nov. 1	—	—	—	—	48	48	2267	100.0
Totals	*11*	*31*	*107*	*438*	*1679*	*2267*		

The jars were then placed in an outdoor insectary and, at the end of 2 to 3 weeks, data were taken as to the number that pupated and the number failing to pupate from each date of collection and in each group of trees. Failure to pupate within a 2-week period from time of maturity was considered proof that that particular larva had entered hibernation. The hibernating larvae in the pupation sticks were grouped according to the date they matured and kept in the insectary until emergence ceased the following spring. During spring emergence, moths were removed daily and records kept so that at the end of the emergence period it was possible to obtain the percentage of each group that completed development.

Other records were obtained in 1944 at Westville and Konawa, Oklahoma, and in 1945 in a second orchard near Stillwater. In these orchards there were not sufficient trees of different ripening dates to operate as in the experiment station orchard and, therefore, only records of hibernating larvae according to the date they matured were obtained.

In 1942 very poor codling moth control was obtained in the Perkins orchard. As a result there was a heavy carry over of overwintering larvae and a heavy spring emergence of moths in 1943. Late summer and early fall conditions in 1943 were unusually favorable for continued breeding of the moths, resulting in a larger than usual number of late September and October or fourth brood worms. There was much better worm control in 1943, 1944 and 1945.

In a few cases the apples were not gathered during the period normally considered their best picking time, but since this had but slight effect on the final results, no attempt was made to make adjustments for such variations.

RESULTS AND DISCUSSION.—The combined data obtained in the Perkins or-

Table 2.—Average number of hibernating larvae per tree, Oklahoma Experiment Station Orchard, Perkins, Oklahoma, 1943, 1944 and 1945.

Date of Ripening	By June 30	July 1–15	July 16–31	August 1–15	August 16–31	September 1–15	September 16–30	After Sept. 30
1943	.1	0	0	.3	1.6	1.7	11.1	24.4
1944	0	0	.33	0.14	1.86	3.50	5.14	6.92
1945	0	0	0	0.46	0.29	2.11	3.67	6.10
Ave. for 3 years	0.33	0	0.30	0.26	1.29	2.23	6.74	13.99
	Ave. of early .08						Ave. of late 8.56	

chard for the three-year period covered in this experiment (table 1) show that a very small percentage of the total hibernating population was taken from trees maturing by the middle of August. Only 13 larvae of the total of 2267 hibernators, or 0.57 per cent, originated from trees maturing fruit by August 15. Since there were 3.1 times as many late as early varieties, this percentage should be multiplied by 3.1 to equalize the difference in the numbers of trees banded giving 1.77 per cent.

Table 2 shows the average number of hibernating larvae per tree for all groups of trees ripening before August 15 was 0.08 and for those ripening after August 15 it was 8.56. Translated into terms of 1000-tree orchards, the relative numbers of hibernating larvae would be 80 in the early orchard and 8560 in the late.

Table 3 shows by 5-day intervals the percentage of the total hibernating population occurring in each orchard each year the experiments were conducted. Since we have set mid-August as the time when all fruit must be removed from the orchard according to the plan proposed,

Table 3.—Percentage of total hibernating populations collected all orchards.

Location and Date	Perkins 1943	Perkins 1944	Perkins 1945	Stillwater 1945	Westville 1944	Konawa 1944	Total of All
June 25	.06				.07		.04
30	.06			.01	.07		.06
July 5	.13			.01	.07		.08
10	.13	.75	.31	.02	.14	.45	.21
15	.32	1.0	.31	.32	.29	.45	.37
20	.45	1.2	.31	.32	.79	.45	.56
25	.45	2.5	.31	1.4	1.1	.45	1.01
30	.58	3.0	.61	2.4	2.2	3.1	1.77
Aug. 4	.58	3.7	3.4	4.6	5.8	4.5	3.56
9	.58	5.5	5.5	7.8	8.5	8.5	5.54
14	.90	9.7	9.5	12.2	14.3	11.2	8.97
19	1.4	11.7	14.4	17.9	24.1	17.0	13.9
24	4.3	20.4	21.4	29.4	35.5	22.3	22.0
29	11.3	34.9	29.7	34.7	46.8	27.7	30.4
Sept. 3	24.6	44.1	39.1	44.6	58.1	48.2	42.1
8	29.2	66.6	45.0	49.5	66.5	69.6	50.0
13	35.2	73.3	69.4	65.9	74.4	77.7	60.3
18	42.2	78.1	69.4	80.2	82.5	86.2	68.8
23	45.7	85.8	88.7	87.8	87.7	91.9	75.2
28	60.6	93.3	88.7	87.8	95.6	98.2	82.7
Oct. 3	67.1	96.0	92.7	96.6	100.	100.	88.5
8	75.2	98.5	99.7	96.6			91.6
13	78.8	99.8	100.	100.			93.6
18	84.7	100.					95.4
23	88.4						96.5
28	96.9						99.1
Nov. 1	100.						100.
Total	1539	401	327	1250	1401	244	5162

it is interesting to note that only 8.97 per cent (463 larvae) of the total hibernating population had entered hibernation on August 14. In other words, approximately 91 per cent of the hibernating population would have been eliminated if the apples from all trees had been picked by August 15. The smaller percentage of larvae entering hibernation by August 14 in the Perkins orchard as compared to the percentage hibernating in the other orchards is accounted for by two factors:

1. There was an exceedingly large number of fourth brood larvae in 1943, and during the year no data were taken excepting in the Perkins orchard. Had data been taken in the other orchards in 1943, it is probable that the percentage that had hibernated by August 14 would have been lower.

2. Picking was completed earlier in the other orchards, which resulted in a smaller proportion of hibernating larvae originating from late moths.

It should be remembered that all collections were made in orchards containing a high percentage of fall ripening varieties. If only varieties that ripened by mid-August had been present in these orchards at the beginning of the season, theoretically 8.97 per cent of the population under the existing conditions would have been found. This should have reduced the mid-August hibernating population of 463 to 8.97 per cent of this number or 42 larvae. Forty-two is but 0.81 per cent of the total hibernating population actually collected. In other words, the plan suggested would theoretically reduce hibernating populations by more than 99 per cent.

Another factor in evaluating the proposed plan of control is the numerous hazards that larvae must undergo during hibernation. Throughout the time these collections were being made, numerous predators were found under the bands. Unfortunately, no records were made concerning their numbers and species, but Carabids, Ostomids (adults and larvae), Chrysopid larvae, *Collops* larvae and ants of various species were commonly found feeding on the larvae. When the larvae were placed in pupation sticks and stored in jars, it was found necessary to protect the jars from ants to prevent complete extermination. Since such hazards are more intense as long as warm weather lasts, it seems highly probable that larvae entering hibernation in early summer would suffer greater mortality from predators than the late hibernators because they are exposed to such hazards over a much longer period of time.

Still another factor is found in records of the relative percentages of emergence among early and late hibernating larvae taken from the Perkins orchard. From 40 larvae that matured before August 15, 17 moths emerged, or 42.5 per cent. On the other hand, 1704 moths emerged from the 1886 larvae maturing after August 15, or 90.03 per cent. While the total number of early hibernating larvae was low, these records indicate that this factor might further reduce the moth populations in orchards planted only to earlier varieties.

The writer, with the assistance of his colleagues, has compiled a list of factors that might tend to counterbalance the advantages of the proposed plan. Such factors are:

1. Proximity to other orchards containing late maturing varieties.

Late apples in close proximity unquestionably would have a distinct adverse effect. However, Doinikov (1936) observed that early varieties separated by a distance of 220 yards from later varieties suffered much lighter injuries than those interplanted with late varieties, and Isely (1939) shows that early fall apples in the same orchard with later varieties but planted in isolated blocks suffer less injury than the same apples interplanted with late varieties. These observations, together with studies of flight habits of codling moths, indicate that the suggested plan would be distinctly advantageous even though late apples were immediately adjacent. However, in practice, it is the writer's opinion that one should attempt to isolate an orchard of early apples from late apples by a quarter-mile or farther.

2. Under this plan, a one-generation strain of moths might be produced in which a high percentage of the first brood of larvae hibernated.

Even though this should occur, the problem would still be reduced to the proportions now existing in the one-generation areas, which certainly would be a great improvement over present con-

ditions in Oklahoma. On the other hand, the writer can see only one reason why one-generation strains might build up faster in an orchard containing only early apples and that is the possibility that larvae feeding on nearly mature fruits might be more likely to hibernate than those feeding on greener fruits. To test this theory a count was made of all larvae, both transforming and hibernating, collected from trees in the Perkins orchard maturing fruit before August 15. The total was 657 larave, 2.43 per cent of which hibernated. The number collected before August 15 from the later trees was 1755, and of these 2.17 per cent hibernated. It is improbable that this difference is significant. These results are in agreement with Isely (1939) who states, " . . . records were kept in 1936 and 1937 of the apple varieties and the time of ripening on the trees from which they were collected. No relation was indicated between the transformation of larvae and the relative ripeness of the fruit on which they developed."

3. Even though the plan greatly reduced the overwintering population, those remaining may constitute a serious problem.

This is a distinct possibility, but the evidence available indicates that if the theoretical reduction can be achieved or even approached, those remaining could readily be controlled. Numerous workers have published statements to the effect that the seriousness of the codling moth problem is in direct proportion to the size of the first brood. It is self evident that the size of the first brood is affected by the number in hibernation. This certainly is logical; and it likewise is logical to believe that the greater the reduction of populations, the less the injury.

Two orchards that support this thesis have been observed by the writer for the past 3 years. In one of these orchards the bearing trees are all of the Yellow Transparent variety, ripening in late June and early July. Although this orchard was poorly sprayed two of the three years and not sprayed at all the other year, less than one per cent of the apples have been wormy in each of the three years.

The other orchard is composed largely of early summer varieties, but has late July and early August varieties in it. This orchard has been sprayed regularly with the dormant, calyx and one-cover spray, but in an indifferent manner. In this orchard counts of apples at harvest in each of the last three years have shown less than 1 per cent of the apples injured by codling moth larvae.

Therefore, summing up all the information available, it appears that the suggested plan would effectively reduce codling moths to a pest of minor importance.

EXPENSE AND PRACTICABILITY.—It is believed that this plan is not only effective but is likewise inexpensive and practical. The plan is inexpensive if adopted before the orchard is set out, and is so self-evident that no further discussion is required. It is true, however, that so far as orchards now in production are concerned, it is neither inexpensive nor practical.

The question as to whether or not this plan is practical is primarily a horticultural problem. Accordingly, the ideas expressed in the following paragraphs were largely arrived at through discussions of the problem with the experiment station horticulturists, apple growers and apple buyers of the state. Needless to say, not all were in agreement; but the consensus of opinion of a high percentage of those interviewed was that the plan is practical.

The basic reason for considering the plan practical is because earlier apples can be produced more economically under Oklahoma conditions than the later varieties, and the earlier varieties normally bring higher prices on the market than those maturing during the fall.

The abundant rainfall of the spring months furnishes sufficient moisture for maturing early apples and since they require a minimum of spraying, spray injury is light. They are exposed for a shorter period to insects, hail and wind injury and usually are picked before extreme heat and drouth injury becomes serious.

Late apples are exposed to such hazards over a much longer period of time. They suffer from lack of moisture during the hottest part of the year and are delayed in development. Heavy dropping decreases the size of the crop and increases the per bushel cost of production. The worm control problem necessitates greater spray expenses and frequently results in spray injury. All these factors detract

from the appearance of the late apples and affects their market price. Also, hot weather is unfavorable for the development of good color in apples.

Another factor having a definite bearing on the price of any commodity is the quality and quantity of competitive products offered for sale at the time it reaches the market. Oklahoma's location on the southern border of the apple belt is a distinct asset in regard to the market situation at the time the early apples reach the markets. Since the major portion of the apples of the United States are produced in more northern areas or in higher altitudes, most of the competing crops come on to the market later than the early apples produced in Oklahoma. A very small percentage of the total apple crop reaches the markets during the summer months, and those arriving have little, if any, advantage in appearance or quality over those produced in the state.

However, starting in early September, a very definite change in the situation occurs. At this time apples from higher altitudes and more northern latitudes begin arriving on the markets. These apples, because of more abundant summer moisture either from rainfall or irrigation and having been grown in cooler climates, the resulting better color, shorter growing season, and shorter spray schedules, are usually definitely more attractive than those being harvested in the state at this time. Such conditions naturally have a depressing effect on the market for Oklahoma apples.

It may be seen that in each of the 10-year periods as well as in the average for all years, prices follow very definite trends. They reach their highest point in May because it is at this time they have been in cold storage longest. They drop rapidly as the new crop begins to appear on the market reaching their lowest point in September. They then climb until the following May. This price trend is particularly interesting in that according to the plan suggested in this paper, the entire apple crop would be marketed in June, July and August, while later apples are for the most part marketed in September, October and November.

Records also show that the average price for the period between 1911 and 1940 is 12 cents per bushel higher during June, July and August than during September, October and November. It, therefore, appears that under the plan suggested, early apples would not only be produced cheaper but would also bring higher prices.

GEOGRAPHIC LIMITATIONS.—An interesting question is: Over what area is this plan workable? Although much data on life histories of codling moths has been published very little is in such a form that one can determine the percentages of the hibernating populations that have entered hibernation by any given date. However much of the published data show that, in general the more northern the latitude or the higher the altitude, the higher the percentages of the first and second brood larvae that enter hibernation; indicating that hibernation starts earlier. Also, the more northern or the greater the elevation of any given orchard, the later the early apples ripen. Therefore, it appears that the period in which apples may be produced without producing large numbers of hibernating larvae is shortened at both ends as one goes northward or higher. As one goes to lower elevations or southward from Oklahoma, one soon enters an area where apple trees do not produce well, presumably because they do not have a sufficiently long dormant period to enable them to set a good crop of fruit the following year. These factors indicate that the area where this plan is applicable has definite limits.

SUMMARY AND CONCLUSIONS.—It is suggested that the plan of planting orchards in which all varieties are mature and harvested by August 15 would greatly reduce the codling moth problem in Oklahoma orchards.

Pupation and hibernation records of larvae collected from trees grouped according to their date of ripening indicate that only approximately nine per cent of the total hibernating population had entered hibernation by August 15, and that less than 2 per cent hibernated on the trees maturing fruit by August 15.

The plan is considered inexpensive and practical for Oklahoma conditions because it costs no more to set out this type of orchard and early apples are more economically produced and normally bring higher prices.

The writer is the first to admit that, with the present information, the plan proposed in this paper is based to a con-

siderable extent on theory and that many theories fail to work when put to the test of practical application. Plans have been made and are already under way which it is hoped will give more complete information than that now available. But until, and unless, further information disproves that herein presented, it is the writer's belief that the plan of growing orchards as outlined above constitutes an effective, inexpensive and practical method of reducing codling moth to a pest of minor importance in Oklahoma orchards.—12-18-45.

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Timing Spray Applications to Control the Pecan Nut Casebearer

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Nickels (1938) has shown that the effective period for applying spray treatments for the control of the pecan nut casebearer, *Acrobasis caryae* Grote, is about one week, beginning when 25 per cent of the first-generation eggs present have hatched. He found that this period can be determined in different localities by collecting and observing the time of hatching of first-generation eggs found on pecan nuts. Observations on the emergence of spring-brood moths under caged conditions and in orchards have been used for determining when to begin collecting the eggs.

In an effort to develop a simpler method for timing spray applications, studies were conducted during the springs of 1943 and 1944 at and near Brownwood, Texas, to determine the relationship of the time that different pecan varieties develop receptive stigmas and shed their catkins to the development of the nut casebearer, and to the time that spray should be applied.

FLOWERING HABITS OF THE PECAN.—The pecan blooms in the spring, soon after the new shoots push out. The flowers are of two types—the conspicuous, long catkins, or staminate flowers, and the smaller pistillate flowers. Pecan varieties are divided into two groups on the basis of their blooming habits. In the first, or protandrous, group the majority of the anthers ripen and the pollen sheds before the stigmas of the pistillate flowers are receptive. This group includes the Western Schley, Success, and Nelson varieties. In the second, or protogynous, group most of the stigmas become receptive before the anthers ripen. Common protogynous varieties are the Eastern Schley, Burkett, and Mahan. Shortly after the pollen is released the catkins begin to drop off, and within a few days they have all dropped. During this study these stages occurred before the first-generation eggs started hatching in appreciable numbers.

EXPERIMENTAL OBSERVATIONS.—Observations on the development of the pecan nut casebearer were begun in the orchard during the period in which overwintering larvae were leaving their hibernacula on the varieties Burkett, Eastern Schley, and Success. The following data were obtained: (1) The period during which larvae leave hibernacula on these varieties; (2) the time of pupation of

[1] The writer expresses his appreciation for helpful suggestions to C. B. Nickels, under whose supervision these studies were performed, and to C. L. Smith and L. D. Romberg.

overwintering larvae collected in the field; (3) the time of emergence of spring-brood moths; and (4) the time of hatching of first-generation eggs collected on nuts and examined in the laboratory.

Observations of blossom development were made on pecan trees 11 or more years of age growing in orchards. The beginning of stigma receptivity in clusters of the pistillate flowers was determined by the pollen-adherence method (Smith & Romberg 1941). The time when 85 to 100 per cent of the catkins had fallen from the trees of three varieties included in this study was determined from observations and estimates of the percentage of the catkins shed at intervals during the shedding period.

Table 1.—Cumulative records of emergence of 411 pecan nut casebearer moths of the spring brood and hatching of first-generation eggs, Brownwood, Texas., 1943.

Date of Observation	Moth Emergence (Per Cent of Total)	First-Generation Eggs	
		Number Collected	Per Cent Hatched
May 4	0.2	—	—
5	.5	—	—
7	3.4	—	—
8	3.9	—	—
9	3.9	—	—
10	5.8	—	—
11	6.8	11	0.0
13	12.9	31	6.5
14	14.4	30	6.6
16	28.5	—	—
17	56.4	61	8.2
18	75.7	115	31.5
19	84.2	—	—
20	89.3	112	25.0
21	89.8	—	—
22	89.8	113	45.1
24	95.6	—	—
25	95.9	145	49.0
26	97.3	—	—
27	98.5	—	—
28	99.3	—	—
29	99.5	—	—
31	100.0	—	—

CASEBEARER DEVELOPMENT AND BLOSSOMING STAGES.—Records of the emergence of spring-brood moths and the hatching of first-generation eggs are summarized in tables 1 and 2.

Prior to moth emergence in 1943 pollen liberation was first observed on Burkett and Eastern Schley April 29. Eight per cent of the pistillate clusters on Western Schley contained receptive stigmas by this time. By May 2 receptive stigmas were observed on 49.4 per cent of Western Schley clusters and 4.0 per cent of Success clusters. Receptive stigmas were visible on 17 per cent of Success clusters 2 days later. By May 10, 95 per cent or more of the catkins had dropped from 80 per cent of the Burkett trees, from practically all Eastern Schley trees, and from about 67 per cent of the Mahan trees.

Before moth emergence in 1944 the first pollen liberation was observed on Burkett on April 28, and 3 per cent of the pistillate clusters on Nelson contained receptive stigmas by this date. Receptive stigmas on 19.2 per cent of Western Schley clusters were in evidence by May 3, and on 12.3 per cent of Success clusters by May 6. Observations on May 15 revealed 95 per cent or more of catkins shed from 90 per cent of the Burkett trees, from all Eastern Schley trees, and from about 60 per cent of the Mahan trees.

The interval between the first-observed date of stigma receptivity on the variety

Table 2.—Cumulative records of emergence of 647 pecan nut casebearer moths of the spring brood and hatching of first-generation eggs, Brownwood, Texas, 1944.

Date of Observation	Moth Emergence (Per Cent of Total)	First-Generation Eggs	
		Number Collected	Per Cent Hatched
May 10	0.2	—	—
11	.3	—	—
12	.3	—	—
13	.8	5	0.0
14	1.2	—	—
15	3.9	10	0.0
16	7.9	—	—
17	16.7	—	—
18	24.3	—	—
19	35.5	286	27.3
20	43.4	—	—
21	54.4	—	—
22	66.9	—	—
23	75.3	—	—
24	84.1	168	47.0
25	89.3	79	54.4
26	89.9	—	—
27	94.3	—	—
29	97.2	431	70.5
30	98.1	—	—
31	98.8	—	—
June 1	98.9	—	—
2	99.7	—	—
3	99.7	—	—
4	99.8	—	—
5	99.8	—	—
6	100.0	—	—

Success and the most suitable date to begin spray applications for the control of the nut casebearer was nearly the same in both years, being 15 and 16 days. Certain other varieties of the protandrous group may develop receptive stigmas 3 weeks before the time to begin spraying. The interval between the date on which 85 to 100 per cent of the catkins had dropped from certain varieties of the protogynous group (Burkett, Eastern Schley, and Mahan) and the date to begin the spraying was 8 days in 1943 and 4 days in 1944. In 1943 the period required for pollen liberation and catkin shedding was short.

The work at Brownwood was supplemented by less extensive observations at Comanche and Rising Star. In general these observations confirmed those made at Brownwood, although in 1944 severe injury caused by a freeze on March 28–29 at Rising Star delayed development on the trees that produced flowers.

CONCLUSIONS AND RECOMMENDATIONS. —It appears from the data that there may be sufficient correlation between the time of blossoming stages on certain varieties of pecans and the time when nut casebearer eggs are deposited and hatch to serve as a basis for determining spray dates for the control of this insect. The time at which 85 to 100 per cent of the catkins had dropped from the varieties Burkett, Eastern Schley, and Mahan more nearly indicated the time to spray than the time when certain other varieties developed receptive stigmas. However, the method for determining the beginning of stigma receptivity is simple, and it may be desirable to use these observations under some conditions.

Pending further study, it is suggested that the spray applications be timed to begin from 4 to 8 days after 85 per cent or more of the catkins are shed from these varieties. Observations may be made relative to the abundance of first-generation eggs in the orchard for determining whether to begin spraying on the fourth or the eighth day. Under conditions in Texas the sprays should be applied usually during the second week after the shedding of 85 to 100 per cent of the catkins. Approximately 25 trees located in different parts of the orchard should be used to determine this time.

It appears possible to substitute other pecan varieties of the protogynous group for those observed in this study, provided the proper adjustments are made for differences in the time of shedding pollen.—1-14-46.

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Azobenzene as an Acaricide and Insecticide

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In the study of synthetic organic chemicals as parasiticides, commercially valuable products may be overlooked because of failure to apply them in the proper manner to the organisms against which they are effective.

Azobenzene had been known for one hundred years before being tested as an insecticide. Following the initial testing, there was no immediate widespread use of this compound because of the failure to develop suitable methods of application, and because of the failure to test it against a wider variety of insect pests.

Fink & Vivian (1936) reported in a short note that they had found azobenzene and substituted azobenzenes to be effective in killing mosquito larvae. They used a concentration of 1 to 200,000 in water, applying the insecticide as a solution in acetone.

Subsequent work in the Bureau of Entomology and Plant Quarantine by Swingle *et al.* (1944) showed that a pure azobenzene dust applied in the laboratory gave good control of certain insects, but that it was ineffective against other species. Field tests by Questel *et al.* (1941)

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against the European corn borer, *Pyrausta nubilalis* Hbn., gave a 59.1 per cent reduction in borer population as against 93.8 per cent for a standard derris spray containing 4 per cent rotenone.

In spite of the reported indications of insecticidal action by the azobenzene series, these compounds were not successfully developed commercially until recently when new types of dusts were made available.

The present paper reports the specific action of these azobenzene dusts against certain species of insects and arachnids. This action is directed against several species which have been, in general, poorly controlled by commercial synthetic organic insecticides. Satisfactory control was obtained on the following pests:

Colorado potato beetle, Mexican bean beetle, eastern tent caterpillar, European corn borer, red spider mite.

SPECIFIC ACTION OF AZOBENZENE.—The action of azobenzene against insects is not universal. Several species have been observed to be highly resistant. Azobenzene has been found to have little effect on the squash bug, several species of aphids, and the greenhouse leaf tier on chrysanthemum. The report by Swingle *et al.* previously referred to also lists 4 species resistant to azobenzene.

INSECTICIDAL ACTION OF AZOBENZENE DUSTS.—The experimental work was initiated using the screening test developed by H. G. Guy (1937). A 4-inch to 6-inch plant of a suitable host species was planted in a 6-inch flower pot. A light coating of the finely powdered insecticidal dust was then applied by means of a small cylinder-type hand duster. The plant was covered with a tubular glass cage, and 10 field-collected insects of the desired species and growth stage were introduced. The open top of the tubular cage was closed by means of cheesecloth, and the experiment observed for 3 to 7 days.

By the use of this technique, it was demonstrated that a dust containing 10 per cent of azobenzene in bentonite gave excellent control of the Colorado potato beetle and the Mexican bean beetle. The effect of this dust is shown in table 1.

Satisfactory control of the eastern tent caterpillar, *Malacosoma americana* Fab., was obtained by using azobenzene. Small larvae of this species were treated with a dust containing 10 per cent of azobenzene and 1 per cent of a surface active agent, (*Nacconol NR*), in bentonite. Twigs supporting colonies of this insect were dusted, and observed for 48 hours. The kill was 90 per cent.

An interesting result was obtained on a field trial against the European corn borer, *Pyrausta nubilalis* Hbn. A 4-row strip was dusted with a 20 per cent azobenzene-80 per cent whiting dust by means of a 4-row duster mounted on a tractor. Two dustings were made 7 days apart, early in July, at the rate of 30 pounds per acre. On a comparative plot two commercial insecticides were employed. On harvesting, the azobenzene treatment gave 62 per cent clean ears against 42 per cent clean ears on the comparative experiment.

Table 1.—Action of 10 per cent azobenzene dusts (in bentonite)

INSECT	TIME OF EXPT.	PER CENT KILL	
		Expt.	Control
Colorado potato beetle Adults	7 days	100	0
Mexican bean beetle Larvae	5 days	100	0
Mexican bean beetle Adults	3 days	100	0

ACARICIDAL ACTION.—Good control of the red spider mites has been obtained in laboratory and greenhouse tests on several species of host plants.

The initial experiment with a dust of 20 per cent azobenzene in bentonite, ground in a *Mikro-pulverizer*, gave a 100 per cent kill. This experiment was conducted in the laboratory on rose twigs in vases. Confirmatory tests on carnation plants on the greenhouse bench also gave good results. The same dust was applied to 12 inch carnation plants at approximately the customary rate—1 pound to 400 square feet of bench space. After 4 days, the kill, by random sampling of the leaves, was 98.9 per cent. Mites were killed even inside the folded center leaves.

A good indication of ovicidal action was observed, since no small spiders were found on the plot during the next 3 weeks,

whereas eggs were hatching on an adjacent plot sprayed with a commercial insecticide.

Further experiments using full-scale application of 20 per cent azobenzene-80 per cent whiting mixtures to carnations emphasized the excellent control. This mixture has been used in approximately 10 greenhouses. In each case satisfactory control was obtained.

The reaction of the carnation plants to azobenzene has been favorable. No foliage injury has been observed. It has been found possible to dust blooming plants by making a close flower cut immediately before dusting. Under these conditions, a few outer petals were browned on some varieties. Buds fully covered by sepals were uninjured. There was an outstanding increase in the vigor of the plants on which the mites had been destroyed. In the first carnation experiment referred to above, the treated 12-inch carnation plants grew 6 inches more than the untreated plants during the 3-week observation period. An improved leaf coloring was also observed.

Greenhouse operators have been particularly well satisfied with freedom from worker complaints during and following the application. The azobenzene dusts have a mild, sweet odor, and are applied with a minimum of discomfort to the operator.

CONCENTRATION REQUIRED.—Leaves from a plant of Angels Trumpet (*Datura*), badly infested with red spider, were dusted with *Mikro-pulverized* azobenzene-whiting dusts of various concentrations. The kills obtained after an observation period of 48 hours are shown in table 2.

Table 2.—Action of azobenzene-whiting dusts on the red spider mite

PER CENT CONCENTRATION OF AZOBENZENE	PER CENT KILL IN 48 HOURS
20.	100.
5.	100.
2.	95.4
1.	94.3
0.5	80.8

FUMIGATING ACTION.—The most recent modification of the use of azobenzene against red spider is the fumigation technique developed by Blauvelt (1945).

Dr. Blauvelt fumigated rose houses by the use of a paste of water and a mixture of 70 per cent azobenzene-30 per cent *Celite 209*. This paste is painted on the cold steam pipes, then the heat is turned on to vaporize the azobenzene. The dosage is 1 pound of the 70 per cent mixture to 40,000 cubic feet of space. Kills from 90 to 99.75 per cent were reported for all stages of red spider mite including the egg stage. This method of application has found ready acceptance by the rose growers.

SUMMARY.—Commercial parasiticides using azobenzene as the active ingredient have been developed. These compositions like other parasiticides, are specific in their action.

The use of dusts containing 20 per cent of azobenzene in whiting or bentonite results in the complete control of several species of economically important pests. These dusts are particularly effective against red spider mite and the Mexican bean beetle, which have previously been difficult to control.—12-5-45.

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SCIENTIFIC NOTES

Benzene Hexachloride to Control Bugs on Cotton

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In an effort to find a more effective insecticide for the control of hemipterous insects that seriously reduce the yield and grade of cotton in Arizona and other sections of the Southwest, preliminary tests with benzene hexachloride (1,2,3,4,5,6-hexachlorocyclohexone) were conducted on the principal injurious species in cages and in one small field plot test. The principal injurious species are the pentatomids *Euschistus impictiventris* Stål., *Chlorochroa sayi* Stål., and *Thyanta custator* (F.), and the mirids *Lygus* spp., *L. hesperus* Knight predominating, *Creontiades femoralis* Van D., and *Adelphocoris superbus* (Uhler). Several other species such as *Psallus seriatus* (Reuter), *Dysdercus mimulus* Hussey, and *Chlorochroa ligata* (Say), are of minor importance in Arizona. Profitable gains in yields of seed cotton from the control of these insects have been made over a period of years by the proper use of sulfur-arsenicals, (mainly 7.5 per cent paris green—92.5 per cent sulfur), but the results have been variable. DDT and sabadilla mixtures have also proved very promising, but still better control is needed, especially for the stinkbugs. The results obtained with benzene hexachloride to date have been so striking that this progress report is presented for the information of others.

The technical benzene hexachloride was obtained from England by the Bureau of Entomology and Plant Quarantine. One of the materials used in the cage tests was a deodorized product ground with gypsum to contain approximately 2 per cent of the gamma isomer, which is the principal toxic ingredient of benzene hexachloride. The other contained approximately 35 per cent of the gamma isomer and was ground with talc so that the mixture contained about 10 per cent of the gamma isomer. Each material was further diluted with pyrophyllite to the desired concentration of the gamma isomer for some of the cage tests. The benzene hexachloride used in the plot test was a nondeodorized unground material containing approximately 10 per cent of the gamma isomer, which was passed through a 16-mesh screen and diluted with pyrophyllite to contain 1 per cent of the gamma isomer.

CAGE TESTS.—A small series of cage tests with pentatomids and mirids was conducted during July and September on the University of Arizona experimental farm near Mesa. Screen cages, 3 by 3 by 3 feet, were placed over cotton plants, and 10 insects were introduced in each cage. The plants were then thoroughly dusted with a plunger-type hand gun at an estimated rate of 25 to 30 pounds per acre. Check cages were used in each test, and the net mortality was calculated by Abbott's formula. The results are summarized in table 1.

In other tests the caged cotton plants were dusted with benzene hexachloride containing 5 per cent of the gamma isomer at varying periods before the introduction of the insects to determine the residual effect. In one test in which the plants were dusted 90 hours before release of the insects, 90 per cent of the *Lygus* spp. and 20 per cent of *Chlorochroa sayi* were dead after 46 hours. Plants dusted 24 hours before release of the insects showed 100 per cent mortality of *Lygus* spp. after 4 hours and 60 per cent of *Chlorochroa sayi* after 46 hours. On plants dusted immediately before releasing the insects the mortality of *Chlorochroa sayi* was 80 per cent and of *Euschistus impictiventris* 60 per cent after 46 hours.

Table 1.—Cage tests with benzene hexachloride containing different percentages of the gamma isomer, against pentatomids and mirids, Mesa, Ariz., 1945.

SPECIES	INSECTS TESTED	GAMMA ISOMER	INTERVAL AFTER TREATMENT	NET MORTALITY
	Number	*Per cent*	*Hours*	*Per cent*
Chlorochroa sayi	20	1	28	75
	20	2	8	85
	30	10	19–43	100
Euschistus impictiventris	20	2	8–28	95
	30	10	19–43	100
Lygus spp.	60	5	3	100
Creontiades femoralis	10	5	15	100

Although no tests were made with other insecticides at this time, comparisons with previous tests show that the mortalities were considerably higher than usually obtained with the sulfur-arsenical mixtures and somewhat greater than with DDT or sabadilla. In all tests benzene hexachloride killed the insects more quickly than did the sulfur-arsenical mixtures or DDT. In the tests with *Lygus* spp. all insects that were not dead within one hour were on their backs.

FIELD-PLOT TEST.—Eight rows of short staple cotton 260 feet in length located on the experimental farm of the University of Arizona were used in the plot experiment. This cotton had been planted for experimental purposes and was exceptionally uniform. Four rows were treated with unground benzene hexachloride containing 1 per cent of gamma isomer, and four were left untreated as a check. The dusting qualities of this material were only fair, but a very good coverage was obtained with a rotary hand gun. The treated plot was dusted four times during the season soon after daylight on the mornings of July 20, 27, August 3 and 17 at the approximate rate of 20 pounds per acre at each application.

Population counts made before the first application showed the mixed population of injurious Hemiptera to be 15 per 100 net strokes, which was the peak reached in the check during the season. Unfortunately, the populations in this field were lower throughout the season than are generally found elsewhere in the State. These population records were continued at weekly intervals until September 5 and averaged 4.1 injurious Hemiptera per 100 net strokes after dusting was begun in the treated plot as compared with 7.3 in the check.

The computed final yield was 2297 pounds of seed cotton per acre for the treated plot and 1547 pounds for the check, or a gain of 750 pounds.

There was no injury to cotton from benzene hexachloride in any of the tests.—12-5-45.

[1] The authors were assisted by John M. Breazeale.

Mosquito Collections at Army Installations in the Fourth Service Command, 1943

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Mosquito collections are made weekly at Army installations in the Fourth Service Command and forwarded to the Fourth Service Command Medical Laboratory for identification or confirmation. Summaries of these weekly mosquito collections for 1943, listed by species, seasonal occurrence and localities, are shown in tables 1 to 7.

Four kinds of collections are included: resting station, light trap, biting, and larval. In most camps natural shelters such as buildings, culverts, bridges and hollow trees were utilized in making resting station collections. However, artificial shelters including mail kegs, red boxes and specially constructed privy-like buildings were used on several posts. The New Jersey light trap was used for all trap collections. Biting records include both day-time and night-time collections made by either one or two collectors using themselves as bait. The larval specimens were obtained from designated larval stations and also from miscellaneous breeding places.

Due to the fact that the females of *Aëdes atlanticus* Dyar & Knab and *A. tormentor* D. and K. cannot be separated with certainty, they are listed in the tables as *A. atlanticus-tormentor*. Male specimens of these two species were separated by examinations of the male terminalia. Adults listed as *Culex erraticus* (Dyar and Knab), *C. pilosus* (D. and K.), and *C. peccator* D. and K. are males and were determined by examinations of the male terminalia; they are otherwise listed as *Culex* (*Melanoconion*) sp. Female and larval specimens of *Culex pipiens* Linnaeus and *C. quinquefasciatus* Say are listed as *C. quin-pipiens* in areas where both species are known to occur. All records of *C. pipiens* represent male specimens determined by terminalia studies. Adult records of *Anopheles bradleyi* King and *Orthopodomyia alba* Baker are based on characters given by King *et al.* (1944).

The states comprising the Fourth Service Command during 1943 were Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina and Tennessee.

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Table 1.—A summary of mosquito collections at army installations in Tennessee during 1943.

Species	Months of Collection: Adults	Total	Larvae	Total	Localities of Collections[1]
AEDES					
aegypti	Sept., Oct.	3	Sept.	3	6
canadensis	May, Sept.	3	Mar., April, Oct.	97	1, 3, 7, 8
cinereus	April, May	2			4
dupreei	July	1			8
sticticus	April–July	557	April, May	3	1, 3, 4, 6, 8
triseriatus	May–Oct.	34	April–July, Sept.	69	1–4, 6–8
vexans	April–Nov.	1,074	Mar.–Oct.	1,254	1–8
ANOPHELES					
barberi	May–Aug.	6	May	2	3, 6, 8
crucians	June–Aug., Oct.	23	June–Aug.	24	1–8
punctipennis	April–Nov.	819	May–Oct.	982	1–8
quadrimaculatus	April–Nov.	729	July–Oct.	119	1–8
CULEX					
apicalis	May–Nov.	288	April–Oct.	640	1–8
erraticus	June–Oct.	260	June–Sept.	106	1–8
(*Mel.*) sp.	May–Dec.	1,341	July, Aug.	8	1–8
nigripalpus			Aug.	8	2
peccator	July–Oct.	16	Sept.	1	1–4, 8
pipiens	June–Nov.	651			1–8
quinquefasciatus	April–Dec.	348			1–8
quin-pipiens	May–Dec.	1,135	May–Dec.	1,223	1–8
restuans	April–Dec.	1,277	April–Dec.	1,727	1–8
salinarius	April–Nov.	314	Mar., May–Nov.	215	1–8
tarsalis	Aug.–Nov.	49	Oct.	3	1, 3–7
CULISETA					
inornata	Mar.–May, Oct., Nov.	36	Mar.–May, Oct.	96	1, 3, 5, 6, 8
melanura	June, July, Sept.–Nov.	11	Oct.	2	1, 3, 4, 7, 8
MANSONIA					
perturbans	June, Sept.	5			1, 8
ORTHOPODOMYIA					
signifera	July, Aug.	3	June–July, Sept., Oct.	17	2, 3, 7
PSOROPHORA					
ciliata	June–Oct.	29	June–Oct.	40	1–5, 7, 8
confinnis	May–Oct.	768	May–Oct.	870	1–8
cyanescens	July–Sept.	103	Sept.	3	2, 3, 6–8
discolor	May–Oct.	163	May–Sept.	116	1–8
ferox	May–Oct.	75	May–Sept.	45	1–6, 8
howardii	May, June	4	May–July, Sept.	23	1, 2, 4, 6
URANOTAENIA					
sapphirina	May–Nov.	1,129	June–Aug.	30	1–4, 6–8
Total		11,256		7,726	

[1] Locations where collections were made:

1. Dyersburg AAB, Dyersburg
2. Camp Forrest, Coffee and Franklin Counties
3. Kennedy General Hospital, Memphis
4. Memphis Municipal AP, Memphis
5. Nashville AAC, Nashville
6. Second Army Headquarters, Memphis
7. Smyrna AAF, Smyrna
8. Camp Tyson, Paris

Table 2.—A summary of mosquito collections at army installations in North Carolina during 1943.

SPECIES	MONTHS OF COLLECTION: Adults	Total	Larvae	Total	LOCALITIES OF COLLECTIONS[1]
AEDES					
aegypti	Nov.	1	Sept., Oct.	18	1, 3, 5
atlanticus	May–Aug.	69	April–Sept.	188	1, 3, 5, 6, 8
atlan-tormentor	Jan., May–Oct.	2,440	May, June, Aug., Sept.	7	1–3, 5, 6, 8
canadensis	May–Oct.	492	Mar.–Sept., Dec.	1,407	1–9
cinereus	July	1			9
dupreei	July–Sept.	32			1, 5, 6, 8, 9
fulvus pallens	June–Aug.	9	July	4	1, 5, 6
infirmatus	July, Sept.	3			3, 5
mitchellae	April–Aug.	124			3, 5, 6, 9
sollicitans	May–Nov.	12,255			3, 5, 8
sticticus	June, July	5			4, 5
taeniorhynchus	May–Nov.	6,274			1, 3, 5, 6, 8
thibaulti	May, June	9	April, May	10	2, 5
tormentor			June	1	6
triseriatus	May–Sept.	52	Mar.–Sept.	219	1, 2, 4–7, 9
vexans	April–Nov.	4,146	Mar.–Nov.	1,850	1–9
ANOPHELES					
atropos	June–Aug.	11			3
barberi	June, Aug.–Oct.	8			1, 6, 7
bradleyi	May–July, Oct.	42			3
crucians	May–Dec.	4,031	April–Dec.	844	1–9
georgianus			April–Dec.	146	1, 5, 6, 8
punctipennis	Jan., May–Dec.	1,490	Mar.–Dec.	1,155	1–9
quadrimaculatus	Jan., May–Dec.	610	April–Oct.	27	1–9
walkeri	Aug.	1			9
CULEX					
apicalis	Jan., Mar.–Dec.	371	Mar.–Nov.	3,098	1–9
erraticus	June, Aug.–Nov.	17	May–Sept.	150	1, 2, 4–9
(*Mel.*) sp.	Jan., Mar., May–Dec.	574			1–9
peccator	Aug.–Oct.	97	Aug.	1	1–4, 6, 9
pilosus	Sept.	3	Sept.	3	1, 6
pipiens	Jan., June–Dec.	1,081			2–9
quinquefasciatus	May–Dec.	318			1–6, 8, 9
quin-pipiens	Jan., Mar., May–Dec.	4,791	June–Dec.	1,163	1–9
restuans	Jan., April–Dec.	1,006	Jan., Mar.–Dec.	3,448	1–9
salinarius	Mar.–Dec.	2,730	Mar.–Oct.	247	1–9
CULISETA					
inornata	Mar., June, Oct.–Dec.	9	Mar., April	20	2, 3, 5, 6, 9
melanura	Mar.–Dec.	2,849	Mar.–Dec.	328	1–6, 8, 9
MANSONIA					
perturbans	May–Oct.	165			1, 2, 4–7, 9
MEGARHINUS					
septentrionalis	July	1	April–Sept.	29	1, 2, 4, 6
ORTHOPODOMYIA					
signifera	Aug., Sept.	3	Mar.–Sept., Nov.	134	1, 2, 5, 6
PSOROPHORA					
ciliata	June–Sept.	58	May–Sept.	41	1–3, 5, 6, 8
confinnis	May–Oct.	1,432	May–Sept.	932	1–9
discolor	June–Sept.	18	June	2	1, 2, 9
feroz	May–Sept.	529	May–Sept.	38	1–6, 8, 9
horrida	July, Aug.	21			5, 6, 8, 9
howardii	July, Aug.	16	May–Sept.	85	1, 2, 4–6, 8
varipes	July–Aug.	30			1, 5, 8
URANOTAENIA					
lowii			June	1	6
sapphirina	May–Nov.	198	June–Oct.	75	1–3, 5–9
WYEOMYIA					
smithii	June, July, Aug.	3	Mar., May, June, Nov.	15	1, 5
Total		48,425		15,686	

[1] Locations where collections were made:

1. Fort Bragg, Fayetteville
2. Camp Butner, Durham
3. Camp Davis, Wilmington
4. Greensboro AAF, Greensboro
5. Laurinburg-Maxton AAB, Maxton
6. Camp Mackall, Hoffman
7. Moore General Hospital, Swannanoa
8. Seymour Johnson Field, Goldsboro
9. Camp Sutton, Monroe

Table 3.—A summary of mosquito collections at army installations in South Carolina during 1943.

SPECIES	MONTHS OF COLLECTION: Adults	Total	Larvae	Total	LOCALITIES OF COLLECTIONS[1]
AEDES					
aegypti	Aug.	2			8, 12
atlanticus	May–July, Oct.	19	June–Sept.	37	1, 8–10, 12, 13
atlan-tormentor	May–Nov.	649			1, 8–10, 12
canadensis	Mar.–Nov.	174	Mar.–June, Aug., Sept.–Dec.	175	4, 6, 8–12
dupreei	July–Nov.	54	Sept., Oct.	3	9–11
fulvus pallens	July–Sept.	14	Aug., Oct.	44	8, 9, 12
infirmatus	April–Dec.	203	July–Oct.	12	1, 4, 9, 12

Table 3—South Carolina (continued)

Species	Months of Collection: Adults	Total	Larvae	Total	Localities of Collections[1]
mitchellae	Mar.–Nov.	558	July–Oct.	35	1, 2, 5, 8–13
sollicitans	April–Nov.	4,202	June–Sept.	22	1, 5, 8–10, 12
sticticus	May	3			12
taeniorhynchus	May–Nov.	4,118	July–Oct.	27	1, 4, 5, 8, 9, 12
thibaulti	May, June	12			9
tormentor			Aug.	2	12
triseriatus	April–Oct.	35	April, June–Oct.	42	1, 2, 4–6, 8, 9, 11, 12
vexans	Mar.–Dec.	5,957	Mar.–Dec.	804	1, 2, 4–13
ANOPHELES					
atropos	May, June	4			9
barberi	July, Oct.	5			9, 12
bradleyi	April–Dec.	113	June, Nov.	5	1, 5, 9, 12
crucians	Mar.–Dec.	2,921	April–Nov.	263	1–6, 8–13
georgianus			Mar.–Dec.	64	2, 8, 9, 11, 13
punctipennis	April–Dec.	755	April, June–Dec.	487	1–4, 6–11
quadrimaculatus	April–Dec.	1,251	May–Sept., Nov.	33	1–3, 5, 6, 8–12
CULEX					
apicalis	Mar.–Dec.	263	Mar.–Dec.	856	1–13
erraticus	June–Dec.	68	June–Nov.	166	1, 2, 5, 6, 8, 9, 11, 12
(*Mel.*) sp.	April–Dec.	684	July, Sept.	9	1–3, 5, 6, 8, 9, 11, 12
nigripalpus	Aug.–Oct.	14	May, July, Sept., Nov.	25	2, 3, 9–13
peccator	July–Nov.	127			8, 9, 11
pilosus	Aug.–Oct.	12	Oct.	15	9, 12, 13
pipiens	Aug.–Dec.	72			4, 6, 8
quinquefasciatus	June–Dec.	3,702	June–Nov.	474	1–6, 8–13
quin-pipiens	July–Dec.	715	May–Dec.	175	2, 4, 6, 8
restuans	Mar.–Dec.	586	Mar.–Dec.	1,304	1, 2, 4, 6–13
salinarius	Mar.–Dec.	3,003	April–Nov.	125	1, 2, 4–13
tarsalis	Nov.	1			11
CULISETA					
inornata	Mar., April, Sept.–Dec.	66	Oct.	1	1, 6, 8, 9, 12
melanura	Mar.–June, Aug.–Dec.	604	Mar.–Sept., Nov., Dec.	66	1, 2, 4, 5, 8, 9, 11–13
MANSONIA					
perturbans	April–Oct.	138			1, 2, 4, 5, 8–12
MEGARHINUS					
septentrionalis			Aug.–Oct.	4	9
ORTHOPODOMYIA					
signifera	April–Nov.	35	April, July–Oct.	64	2, 4, 8, 9, 11, 12
PSOROPHORA					
ciliata	June–Oct.	116	June–Sept.	38	1, 4, 6, 8–13
confinnis	May–Oct.	3,169	May–Oct.	982	1, 2, 4–13
cyanescens	July	1			8
discolor	Aug.	12			4, 8, 9
feroz	April–Nov.	190	April, June–Oct.	84	1, 4, 6, 8–12
horrida	July	4			8, 11
howardii	July–Aug.	10	July–Sept.	25	1, 9, 12
varipes	July	2			8, 10
URANOTAENIA					
lowii	Oct., Nov.	4			9, 12
sapphirina	May–Nov.	2,290	May, July–Oct.	26	1, 4, 5, 8–12
WYEOMYIA					
smithii			Mar., Oct.	9	8
Total		36,937		6,503	

[1] Locations where collections were made:

1. Charleston AAB, Charleston
2. Columbia AAB, Columbia
3. Congaree AAF, Congaree
4. Camp Croft, Spartanburg
5. Georgetown 144th Infantry, Georgetown
6. Greenville AAB, Greenville
7. Greenwood AAB, Greenwood
8. Fort Jackson, Columbia
9. Myrtle Beach AAF, Myrtle Beach
10. Orangeburg 58th AAFFTD, Orangeburg
11. Shaw Field, Sumter
12. Stark General Hospital, Charleston
13. Walterboro AAB, Walterboro

Table 4.—A summary of mosquito collections at army installations in Georgia during 1943.

Species	Months of Collection: Adults	Total	Larvae	Total	Localities of Collections[1]
AËDES					
aegypti	July, Sept.	21	July	102	2, 4–7, 9–12, 14, 18
atlanticus	May–Aug.	297	June–July	27	2, 6–8, 14, 18
atlan-tormentor	April–Sept.	2,054	May	1	2, 3, 5, 7, 8, 14, 16–18
canadensis	March–Sept.	292	June–Aug.	1,133	2, 3, 7–10, 14–18
dupreei	June–Sept.	6			3, 7, 14
fulvus pallens	July–Aug.	6			1, 17
infirmatus	July–Sept.	36			4, 8, 14, 16, 17
mitchellae	March–Nov.	1,963	March, July, Aug.	31	2, 4, 7, 8, 10, 14, 16–18
sollicitans	April–Sept.	43			8, 14
sticticus	April–June	52			2, 7, 13, 14, 18
taeniorhynchus	May–Oct.	153			3, 7, 8, 14
tormentor	June–Aug.	5			7, 8, 14
triseriatus	April–Sept.	45	Feb.–April, June–Aug.	179	2, 7, 9, 11, 12, 14, 16, 18
vexans	Feb.–Nov.	7,763	Jan.–Oct.	2,345	1–18

Table 4—Georgia (continued)

SPECIES	MONTHS OF COLLECTION: Adults	Total	Larvae	Total	LOCALITIES OF COLLECTIONS
ANOPHELES					
atropos	June	1			14
barberi	May, July, Sept.	3	April	1	2, 9, 14
bradleyi	May	2			8, 14
crucians	Jan.–Dec.	6,999	Jan.–Dec.	2,149	1–14, 16–18
georgianus			Jan.–Dec.	374	2, 5–7, 10, 13, 18
punctipennis	Jan.–Dec.	734	Feb.–Dec.	1,114	1, 2–16, 18
quadrimaculatus	Jan.–Dec.	1,137	May–Nov.	249	1, 2, 4–8, 10–14, 16, 18
CULEX					
apicalis	Feb.–Dec.	451	Jan.–Dec.	3,030	2–16, 18
erraticus	June–Nov.	114	April–Nov.	626	1–8, 10, 12–14, 18
(*Mel.*) sp.	Jan.–Dec.	3,568	June–Sept.	96	1–10, 12–14, 16, 18
nigripalpus	April, June–Dec.	869	May–Oct.	407	1–10, 13, 14, 16–18
peccator	July–Oct.	43	Aug., Oct.	19	2, 5–8, 10, 13, 14
pilosus	July–Oct.	521	July–Aug.	63	2, 4, 6–8, 10, 12–14, 17, 18
pipiens	July	2			11
quinquefasciatus	Jan.–Dec.	7,903	April–Dec.	4,582	1–18
quin-pipiens	July	2	July, Aug.	33	11
restuans	Jan.–Dec.	825	Jan.–Dec.	2,598	2, 4–18
salinarius	Jan.–Dec.	2,800	Jan.–Nov.	374	1–10, 12–18
tarsalis	Sept., Dec.	2			14, 18
CULISETA					
inornata	Jan.–April, June, Oct., Nov.	85	Feb.–May	30	2, 4, 7–10, 12, 14, 18
melanura	March–Nov.	283	Jan.–Dec.	180	2–5, 7–10, 13, 14, 16, 18
MANSONIA					
perturbans	April–Oct.	615			1–4, 6–8, 10, 12, 13, 16–18
MEGARHINUS					
septentrionalis	June	1	June–Sept.	12	7, 18
ORTHOPODOMYIA					
signifera	June, July, Oct.	6	March, May–Nov.	136	2, 5–9, 14, 18
PSOROPHORA					
ciliata	May–Oct.	324	May–Sept.	54	1, 2, 4, 6–10, 13, 14, 17, 18
confinnis	May–Oct.	7,556	April–Sept.	1,471	1–4, 6–17
cyanescens	June–Oct.	36	May, June	2	2, 4, 11, 13, 14, 16, 18
discolor	May–Sept.	779	June–Aug.	86	1–4, 7, 9, 10, 16, 18
ferox	May–Sept.	215	March, May–Sept.	47	2, 4–11, 14, 17, 18
horrida	June–Aug.	16	June	4	1, 2, 11
howardii	June–Aug.	15	May–Sept.	34	2, 4, 7–10, 13, 14, 18
varipes	June	15	June	8	2, 16, 18
URANOTAENIA					
lowii	June–Oct.	94			2, 4, 8, 9, 14, 18
sapphirina	April–Nov.	3,813	April–Oct.	187	1–5, 7–10, 12–14, 18
Total		52,565		21,784	

[1] Locations where collections were made:

1. Battey General Hospital, Rome
2. Fort Benning, Columbus
3. Chatham Field, Savannah
4. Cochran Field, Macon
5. Daniel Field, Augusta
6. Finney General Hospital, Thomasville.
7. Camp Gordon, Augusta
8. Hunter Field, Savannah
9. Fort McPherson, Atlanta
10. Moody Field, Valdosta
11. Fort Oglethorpe, Oglethorpe
12. Oliver General Hospital, Augusta
13. Spence Field, Moultrie
14. Camp Stewart, Hinesville
15. Camp Toccoa, Toccoa
16. Turner Field, Albany
17. Waycross AAB, Waycross
18. Camp Wheeler, Macon

Table 5.—A summary of mosquito collections at army installations in Alabama during 1943.

SPECIES	MONTHS OF COLLECTION: Adults	Total	Larvae	Total	LOCALITIES OF COLLECTIONS[1]
AEDES					
aegypti	June–Oct.	41	Mar., July, Sept.	61	2, 7, 10, 11
atlanticus	Aug.	1	April	1	11
atlan-tormentor	June, July	4			2
canadensis	April, May, Sept., Oct.	8	Jan.-April, June, July	3,243	7, 8, 11, 12
infirmatus	April, May	2	Sept.	1	2, 9
mitchellae	July, Aug.	2			7, 9
sollicitans	July, Sept.	4			2, 7
taeniorhynchus	June, Sept.	2			2, 12
sticticus	Mar.–May	39			2, 7, 11, 13
thibaulti			Feb., Mar.	74	8, 11
triseriatus	May–July	13	Feb.–May, Sept.	116	2, 7, 8, 11, 12
vexans	Feb.–Nov.	1,848	Feb.–Sept.	577	2, 4–13
ANOPHELES					
barberi	June, July, Oct., Nov.	6			2
c. bradleyi	June, Sept.	9			2
c. crucians	Jan.–Dec.	924	Jan.–Nov.	135	1, 2, 4–13
c. georgianus			Jan., April–Sept., Nov.	79	9, 11, 13
punctipennis	Jan., Mar.–Dec.	828	Feb.–Dec.	1,912	1, 2, 4–13
quadrimaculatus	Feb., May–Dec.	3,532	June–Nov.	136	1–7, 10–13

Table 5—Alabama (continued)

Species	Months of Collection: Adults	Total	Larvae	Total	Localities of Collections[1]
CULEX					
apicalis	Jan.–Dec.	116	Jan.–Dec.	2,157	1, 2, 4, 5, 7–13
erraticus	April, June–Nov.	80	May–Oct.	348	1, 2, 4, 5, 7, 8, 10–13
(Mel.) sp.	Feb.–Dec.	547			1–5, 7–9, 11–13
nigripalpus	Aug.–Nov.	24	Sept., Oct.	104	1, 2, 7, 10, 11, 12
peccator	July–Nov.	23	July	3	1, 2, 4, 5, 7, 8, 12
pilosus	July, Aug., Nov.	5	July, Sept.	5	1, 9, 12
pipiens	July, Aug.	7			12
quin-pipiens	July, Sept.	40	Sept.	150	12
quinquefasciatus	Jan.–Dec.	12,555	Jan., Feb., April–Dec.	3,913	1–5, 7–13
restuans	Feb.–Dec.	584	Jan.–Dec.	5,153	2–5, 7–13
salinarius	April–Dec.	261	April–Oct.	286	1, 2, 4, 5, 7–13
tarsalis	Sept.–Nov.	8			4, 8, 12
CULISETA					
inornata	Jan.–May, Sept.–Nov.	24	Mar., April, Oct.	38	2, 7, 8, 10, 11, 12
melanura	June–Dec.	19	Jan., Feb., May, July, Aug., Nov.	91	2, 5, 7, 9, 11
MANSONIA					
perturbans	April–Sept.	69			2, 4, 7, 11, 13
titillans	Sept.	1			2
ORTHOPODOMYIA					
signifera	May, June, Sept.–Nov.	5	Feb.–April, June, July	95	7, 8, 11, 12
PSOROPHORA					
ciliata	May–Oct.	34	May, July, Sept.	18	1, 2, 3, 7, 8, 10, 12, 13
confinnis	May–Oct.	1,858	April–Sept.	542	2–5, 7–13
cyanescens	May, July–Sept.	21	May	2	3, 7, 8, 9, 12
discolor	May–Oct.	153	May, July	9	7, 8, 9, 12, 13
feroz	April, June–Aug.	39	July, Sept.	2	1, 2, 7, 8, 9, 11, 12, 13
horrida	May–Aug.	35			7, 12, 13
howardii	June	1	June, Sept.	6	2, 8, 10
varipes	May	7			7
URANOTAENIA					
lowii	Aug., Sept.	2			7, 12
sapphirina	May–Oct.	219	July–Sept.	25	1, 2, 7–13
Total		24,000		19,282	

[1] Locations where collections were made:

1. Aliceville Internment Camp, Aliceville
2. Brookley Field, Mobile
3. Courtland AAF, Courtland
4. Craig Field, Selma
5. Gunter Field, Montgomery
6. Huntsville Arsenal, Huntsville
7. Maxwell Field, Montgomery
8. Fort McClellan, Anniston
9. Napier Field, Dothan
10. Opelika Internment Camp, Opelika
11. Camp Rucker, Ozark
12. Camp Sibert, Attalla, St. Clair and Etowah Counties
13. Tuskegee AAF, Tuskegee

Table 6.—A summary of mosquito collections at army installations in Mississippi during 1943.

Species	Months of Collection: Adults	Total	Larvae	Total	Localities of Collections[1]
AËDES					
aegypti	July–Nov.	31	Jan., July–Sept.	55	4, 7–12, 14–16
atlanticus	June, Aug., Oct., Nov.	10	April, Aug., Sept.	95	7, 9, 14, 15
atlan-tormentor	June–Aug., Oct., Nov.	31			2, 7–9, 14, 15
canadensis	Mar.–June, Sept., Oct.	63	Jan.–April, June–Sept.	954	2, 4, 5, 7, 12, 14–16
dupreei	June, Sept., Oct.	9	Aug.	2	2, 7, 15
fulvus pallens	July	1			2
infirmatus	April, June, Aug.–Oct.	35			7–9, 12, 16
mitchellae	Mar., June–Oct., Dec.	49	Mar., July, Sept.	83	7–9, 11, 15
sollicitans	May–Oct., Dec.	3,504	July–Nov.	197	4, 7, 9, 15
sticticus	Mar.–June	248	April	2	2, 4, 5, 8, 10, 12, 14, 15
taeniorhynchus	June–Oct., Dec.	366	July–Oct.	203	1, 7–9, 15
thibaulti	April–June	12			2, 4, 12
triseriatus	April–Oct.	81	Jan.–Dec.	565	1, 2, 5, 7–9, 11, 12, 15, 16
vexans	April–Dec.	3,951	Jan.–Dec.	3,082	1–16
ANOPHELES					
atropos	June–Aug., Oct.–Dec.	37	July	21	7, 9, 15
barberi	Mar., May–Aug.	14	June–Aug.	7	2, 5, 9, 12, 15, 16
bradleyi	April–Sept., Nov.	52	June–Sept.	95	7, 9
crucians	Jan.–Dec.	1,709	Feb.–Dec.	286	1–5, 7–16
georgianus			Mar.–Sept., Nov.	83	9, 11, 15
punctipennis	Jan.–Dec.	1,470	Jan.–Dec.	2,307	1–16
quadrimaculatus	Jan., April–Dec.	19,481	Feb., May–Nov.	982	1–16
walkeri	June	2			15
CULEX					
apicalis	Mar.–Dec.	519	Jan.–Dec.	2,850	1–16
erraticus	May–Dec.	875	May–Nov.	820	1–16
(Mel.) sp.	Jan., Mar.–Dec.	6,756	Aug.	2	1–16
nigripalpus	June–Dec.	391	Aug.–Nov.	105	1, 2, 6–9, 13–15
peccator	April–Dec.	128	June–Sept.	63	1, 2, 5, 7, 8, 10–16
pilosus	July–Oct.	16	Sept.–Nov.	35	2, 7, 9, 11, 15
pipiens	Sept., Oct.	15			3
quinquefasciatus	Jan.–Dec.	21,522	Jan., Mar.–Dec.	6,971	1–16

Table 6—Mississippi (continued)

Species	Months of Collection: Adults	Total	Larvae	Total	Localities of Collections[1]
quin-pipiens	Aug.–Oct.	433	Aug.–Oct.	343	3
restuans	Jan.–Dec.	2,296	Jan.–Dec.	7,841	1–16
salinarius	Feb.–Dec.	2,421	Feb.–Dec.	1,035	1–15
tarsalis	Sept.–Dec.	57	Oct., Nov.	5	1, 3–9, 11, 12, 14–16
CULISETA					
inornata	Jan.–June, Sept.–Dec.	2,896	Jan.–April, Oct.–Dec.	482	2–4, 6, 7, 9, 12, 14–16
melanura	Jan.–Dec.	78	Jan.–Mar., May–Aug., Oct.–Dec.	117	2, 3, 7, 9, 10, 12, 14–16
MANSONIA					
perturbans	April–Oct.	46			1, 2, 5, 7, 9, 10–16
MEGARHINUS					
septentrionalis	May–July	3	Jan., July	4	2, 14, 15
ORTHOPODOMYIA					
signifera	June, July, Sept.–Nov.	13	Jan.–Sept.	258	2, 3, 5, 7, 9, 12, 14–16
PSOROPHORA					
ciliata	May–Oct.	25	April, June–Sept.	77	1–3, 5, 7–10, 12–16
confinnis	June–Nov.	2,302	April–Oct.	3,621	1–16
cyanescens	June–July, Sept., Oct.	21	July, Sept.	11	2, 3, 5, 12, 14
discolor	May–Oct.	384	April–Sept.	181	1–5, 7–15
ferox	April–Oct.	430	Mar.–Sept.	138	1–5, 7–9, 11–16
horrida	April, June, July	55			2, 5, 9, 12, 14–16
howardii	May–July	11	April–Sept.	83	2, 5, 8, 12–16
varipes	April, June–Aug.	145			2, 5, 7, 11, 13–16
URANOTAENIA					
lowii	June–Nov.	1,982	Sept.–Nov.	9	1–3, 7, 9, 11, 15, 16
sapphirina	Mar.–Dec.	1,767	April–Oct.	106	1–16
Total		76,743		34,176	

[1] Locations where collections were made:

1. Clinton POW Camp, Clinton
2. Columbus AAF, Columbus
3. Como POW Camp, Como
4. Greenville AAB, Greenville
5. Greenwood AAF, Greenwood
6. Grenada AAB, Grenada
7. Gulfport AAF, Gulfport
8. Jackson AAB, Jackson
9. Keesler Field, Biloxi
10. Key Field, Meridian
11. Laurel AAB, Laurel
12. Camp McCain, Grenada and Montgomery Counties
13. Mississippi Inst. of Aero., Jackson
14. Mississippi Ordnance Plant, Flora
15. Camp Shelby, Hattiesburg
16. Camp Van Dorn, Centerville

Table 7.—A summary of mosquito collections at army installations in Florida during 1943.

Species	Months of Collection: Adults	Total	Larvae	Total	Localities of Collections[1]
AEDES					
aegypti	Feb., Mar., June, Aug.–Sept.	13	June–Sept.	89	5, 7, 8, 16, 20, 29, 31, 41, 42
atlanticus	May–Oct.	100	Mar., May–Nov.	248	2, 5, 7, 8, 15, 16, 18, 20–22, 28, 29, 31, 33, 35, 45, 46
atlan-tormentor	April–Dec.	1,244	Aug., Sept.	10	1, 2, 4, 5, 7, 15, 16, 18, 20, 22, 24, 27–33, 35, 39, 41, 45
canadensis	Feb.–Nov.	92	Jan.–Sept., Dec.	320	5, 7, 15, 20, 28, 29, 39, 41, 45
dupreei	July–Oct.	10			1, 4, 15, 29, 38
fulvus pallens	June–Aug.	8			4, 7, 13, 15
infirmatus	Mar.–Dec.	3,320	Mar., June–Sept., Nov., Dec.	44	1–5, 7, 8, 13, 16, 19, 20, 22–31, 33, 35, 38–41, 43, 45
mathesoni	Sept.–Nov.	2			25, 39
mitchellae	Jan.–Dec.	3,299	Jan.–Mar., May–Sept.	262	2, 4, 5, 7, 15, 16, 18, 20, 22, 25, 28, 29, 31, 33, 35, 38, 39, 41, 45
sollicitans	Jan.–Dec.	2,951	Jan., Mar., May–Sept.	106	2, 4, 5, 7, 15, 16, 18, 20, 22, 28, 33 35, 39, 41, 42, 43, 45, 46
sticticus	Feb.–May	74			15, 29
taeniorhynchus	Jan.–Dec.	63,323	Jan.–July, Sept.	444	2–8, 10, 15–22, 25, 26, 28, 30–35, 38–43, 45–47
thibaulti	April	1			29
triseriatus	Mar.–Oct.	33	Jan., June–Sept.	32	4, 5, 7, 11, 14, 15, 22, 27, 29, 39, 45
vexans	Feb.–Dec.	4,800	Feb.–July, Sept., Nov.	295	1, 2, 4, 5, 7, 8, 11, 15, 16, 18, 20, 22, 27–29, 31, 33, 38, 39, 41, 45
ANOPHELES					
atropos	Feb.–Dec.	1,195	Mar., May–Aug.	55	2, 5, 7, 16, 18, 26, 28, 31, 33, 43, 45
barberi	Mar., April, Oct.	3			29, 31, 45
bradleyi	May–Dec.	148	Oct.	3	2, 5, 33, 43, 45
crucians	Jan.–Dec.	29,730	Jan.–Dec.	9,082	1–41, 43–48
georgianus			Jan.–April, June–Dec.	115	1, 5, 7, 20, 24, 37
punctipennis	Jan.–Dec.	134	Mar.–Aug., Oct.–Dec.	94	1, 4, 5, 7, 8, 11, 15, 16, 20, 22, 24, 27, 29, 32, 33, 36, 37, 40, 45, 47
quadrimaculatus	Jan.–Dec.	7,879	Jan.–Dec.	907	1–23, 25–35, 37–40, 43–47
walkeri	Jan., Feb., April–July, Sept.–Dec.	27			4, 22, 28, 29, 31, 33
CULEX					
apicalis	Jan.–Dec.	299	Jan.–Dec.	744	1, 4, 5, 7, 11, 12, 15, 16, 20–22, 24, 25, 27–30, 33, 35, 38, 41, 43, 45, 48
erraticus	Jan., April–Dec.	946	Jan., Mar.–Dec.	1,337	1–5, 7–9, 11, 12, 14–23, 25, 27–40 42, 45–48

Table 7—Florida (continued)

Species	Months of Collection: Adults	Total	Larvae	Total	Localities of Collections[1]
(Mel.) sp.	Jan.–Dec.	36,325	Jan., Feb., April, June, July, Oct.	24	1–35, 37–41, 44–46
nigripalpus	Jan.–Dec.	41,389	Jan.–Dec.	5,321	1–11, 13–31, 33–47
peccator	June–Oct., Dec.	77	June–Nov.	25	1, 5, 7, 8, 15, 16, 20, 29, 31, 33, 35, 45
pilosus	Mar.–Dec.	2,178	April–Dec.	919	2–5, 7, 8, 11, 12, 15–18, 20–23, 25, 27–33, 35, 38, 39, 45
quinquefasciatus	Jan.–Dec.	8,156	Jan.–Dec.	4,463	1–5, 7–35, 38–43, 45–48
restuans	Jan.–Dec.	409	Jan.–May, Aug.–Dec.	2,393	4, 5, 7, 8, 11, 15–17, 19, 20, 22, 25, 27–29, 33, 35, 38, 39, 41, 45
salinarius	Jan.–Dec.	6,829	Jan.–Dec.	1,675	1, 2, 4, 5, 7–9, 11, 15, 16, 18–23, 25, 27–29, 31, 33–35, 39–42, 45, 47
tarsalis	Sept., Nov., Dec.	3			29
CULISETA					
inornata	Jan.–May, Oct.–Dec.	770	Jan.–Mar., Nov., Dec.	188	5, 7, 15, 16, 18, 20, 22, 28, 29, 31 33, 38, 45
melanura	Jan.–Dec.	1,334	Jan., Feb., April–Dec.	114	2–5, 7–9, 11, 15, 16, 19–22, 24, 25, 27–29, 31, 33–35, 37–39, 41, 44, 45
DEINOCERITES					
cancer	Mar.–Sept., Nov., Dec.	133	Sept.	70	8, 33
MANSONIA					
perturbans	Mar.–Nov.	4,523			1–5, 7, 8, 11, 14–22, 24, 25, 27–29, 31–35, 37, 39, 45–47
titillans	June–Dec.	199	July–Dec.	159	4, 8, 16, 22, 31, 33
MEGARHINUS					
sept-rutilus			Sept.–Nov.	12	7
ORTHOPODOMYIA					
signifera	April, Oct., Dec.	8	July, Oct.	25	5, 7, 10, 27, 29, 45
PSOROPHORA					
ciliata	Mar.–Oct., Dec.	823	Mar.–Sept.	241	1, 2, 4, 5, 7–9, 12, 15, 16, 20, 22, 25, 28, 30, 31, 33, 38, 39, 41, 43, 45, 46, 48
confinnis	Mar.–Dec.	76,600	Jan.–Nov.	3,923	1–5, 7–23, 25–39, 41–43, 45–48, 16
cyanescens	June	1			5, 15, 18, 21, 22, 29
discolor	May–July, Sept.	11	June	1	5, 15, 18, 21, 22, 29
feroz	Mar., April, June–Oct.	347	Mar., June, July, Nov	34	1, 4, 7, 12, 13, 15, 16, 19, 20, 22, 23, 25, 28–31, 33, 37–41, 43, 46, 47
howardii	July, Aug., Oct.	17	May, June, Sept., Oct.	5	4, 8, 20, 21, 29, 31
URANOTAENIA					
lowii	Jan.–Dec.	4,462	Jan., Feb., April–Dec.	177	2, 4, 5, 7, 8, 15–22, 27, 28, 31, 33, 35, 36, 39, 41, 42, 45–47
sapphirina	Jan.–Dec.	6,871	Jan.–Dec.	2,451	1–9, 11, 14–23, 25, 27–29, 31–39, 41, 42, 45, 47
WYEOMYIA					
mitchellii	May, June, Aug.–Oct.	70			4
vanduzeei	Mar.–Oct.	163			4
Total		311,329		36,407	

[1] Locations where collections were made.

1. Alachua AAF (AAFTAC), Alachua
2. Apalachicola, Apalachicola
3. Apopka Unit (AAFTAC), Apopka
4. Avon Park Bombing Range, Avon Park
5. Fort Barrancas, Pensacola
6. Bayport Unit (AAFTAC), Bayport
7. Camp Blanding, Starke
8. Boca Raton Field, Boca Raton
9. Brooksville AAB (AAFTAC), Brooksville
10. Buckingham AAF, Fort Myers
11. Bushnell AP and Unit (AAFTAC), Bushnell
12. Cross City AAB (AAFTAC), Cross City
13. Crystal River Unit (AAFTAC), Crystal River
14. Dade City Unit (AAFTAC), Dade City
15. Dale Mabry Field, Tallahassee
16. Drew Field, Tampa
17. Dunnellon AP (AAFTAC), Dunnellon
18. Eglin Field, Pensacola
19. Eustis Unit (AAFTAC), Eustis
20. Camp Gordon Johnston, Carrabelle
21. Gotha-Minorville Unit (AAFTAC), Gotha
22. Hendricks Field, Sebring
23. Kent Unit (AAFTAC), Kent
24. Keystone Heights AP (AAFTAC), Keystone Heights
25. Kissimmee AP (AAFTAC), Kissimmee
26. Largo Unit (AAFTAC), Key Largo
27. Leesburg Army Instls. (AAFTAC), Leesburg
28. MacDill Field, Tampa
29. Marianna AAB, Marianna
30. Montbrook AP (AAFTAC), Montbrook
31. Morrison Field, West Palm Beach
32. Mount Dora Unit (AAFTAC), Mount Dora
33. Camp Murphy, West Palm Beach
34. Ocoee Unit (AAFTAC), Ocoee
35. Orlando Army Instls., Orlando
36. Orlavista Unit (AAFTAC), Orlavista
37. Pasco Unit (AAFTAC), Pasco
38. Perry AAB, Perry
39. Pinecastle AP (AAFTAC), Pinecastle
40. Plant City Unit (AAFTAC), Plant City
41. St. Augustine Recreation Area, St. Augustine
42. St. Petersburg Army Instls., St. Petersburg
43. Tarpon Springs Unit (AAFTAC), Tarpon Springs
44. Trenton Unit (AAFTAC), Trenton
45. Tyndall Field, Panama City
46. Venice AAB, Venice
47. Winter Garden Unit (AAFTAC) Winter Garden
48. Zephyrhills Unit (AAFTAC), Zephyrhills

The Control of the Blueberry Bud Mite

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The blueberry bud mite *Eriophyes vaccinii* K,[1] is an exceedingly small, white wormlike, four-legged Eriophyid mite about 0.2 mm. long and is invisible to the naked eye. It infests the fruit buds and sometimes the developing fruits of several species of Vaccinium. In the fruit buds it lives between the scales, sometimes in such numbers that 50 or more mites are found in a single bud. Their feeding produces typical gall-like, often reddened, swellings at the bases of the bud scales and on the stem. The scales of infested buds persist, giving a typical rosette appearance Darrow *et al.* 1944. In severe cases the entire crop may be destroyed.

This mite was first reported and described by Keifer (1939), but had caused considerable damage in cultivated blueberry fields in North Carolina for several years previously (Fulton 1940) (Keifer 1941). It was first reported from Massachusetts by Darrow about 1941 (4). It was found on the Harding variety at Amherst but to such a limited extent that it was not considered serious nor likely to become so. In 1934 a picture was made of an unknown blueberry trouble. A study of an enlargement from this negative disclosed that very probably the trouble was blueberry bud mite. Hence, this mite has been in Massachusetts for at least a dozen years.

In the spring of 1945 the fruit buds of part of a row of cultivated blueberries of the Pemberton variety and part of an adjacent row of Wareham in the experimental plantings at Massachusetts State College showed the rosette symptoms of bud mite. Examination under a microscope revealed a very heavy infestation. Later in the season it was estimated that the crop of infested bushes was cut by at least 50 percent.

Since Darrow *et al.* 1944 reported that "no spray application has yet been successful as a control measure," it was decided to try a summer "dinitro" spray. Accordingly on June 11, eight infested bushes of each of the varieties Pemberton and Wareham were sprayed with the Dinitro compound *DN-111*, 4 oz., plus 1.6 gms. of *Ultrawet* spreader and sticker in 20 gals. of water. The spray was applied with a quad nozzle fitted with 0.05 inch disks at 400 lbs. pressure supplied by a power-takeoff sprayer. After 24 hours, severe burning of the foliage of both varieties was observed, and later considerable spotting of the young green fruits was noted. However, the kill of bud mites was very encouraging. Before spraying, Wareham had an average of 54 mites per bud with a range of 17 to 75 mites per bud. Pemberton averaged 59 mites per bud. Twenty-four hours after spraying, 11 live mites were found in 5 Wareham buds and 12 live mites in 4 Pemberton buds, an average of 2.5 mites per bud for the two varieties.

In an attempt to avoid injury to foliage and fruit and at the same time secure control of the mites, a second series of sprays was applied, on June 20 to different bushes of the same two varieties, with the same equipment but with the pressure reduced to 150 to 175 lbs. The *DN-111* was applied at both 16 and 20 oz. per 100 gals. of water plus the spreader and sticker as before. Twenty-four and 48 hours after spraying, the mite population per bud was reduced to the following:

[1] Contribution No. 581 of the Massachusetts Agricultural Experiment Station.

Table 1.—Mite populations after spraying.

	16 OZ. TO 100 GALS.		20 OZ. TO 100 GALS.	
	Pemberton	Wareham	Pemberton	Wareham
After				
24 hours	22	2.6	41	5
48 hours	2.3	3.3	1	0.5

Among buds of the Pemberton variety on which mite counts were made 24 hours after spraying, there was great variation in live mite population. It varied from 0 to 90 mites per bud. In the high count buds no yellow specks of spray material could be found at the base of the scales where the mites reside, indicating that probably such buds were missed in spraying. Such specks were plentiful wherever the mite count was low.

Forty-eight hours after spraying some burning of the foliage and fruit appeared in the form of small, round, brown spots. The concentration of the spray seemed to make little difference in the amount of injury. However, the reduction in pressure appears to have been an important factor since the injury was much less where the lower pressure was used.

Although the control of blueberry bud mite by spraying with *DN-111* is in the early experimental stage, two points are worth noting: (a) In mid-June the spray can be forced down in between the base of the bud scales where it is needed and (b) *DN-111* killed the blueberry bud mites.—12-15-45.

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Collections of Mosquitoes on Parris Island During 1945

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This study was undertaken as a part of the Malaria Control Program under way at the Marine Barracks, Parris Island, South Carolina.

Parris Island is located in Beaufort County, 4 miles southwest of the city of Beaufort, and lies between Beaufort and Broad Rivers at the head of Port Royal Sound.

The Island lies in the coastal plain and is approximately 6 miles long by 3 miles wide. It consists of numerous small "islands" of live oak-palmetto vegetation surrounded by tidal marsh. These "islands" are connected by a system of roadways and larger areas of hydraulic fill. Approximately 40 per cent of the area is tidal marsh and subject to a 10-foot, semi-diurnal tide. The highest elevation is approximately 10 feet above mean high tide level.

The average annual rainfall is 46 inches, with the heaviest rainfall in June, July, August and Septem-

ber. The following gives the monthly rainfall during the collecting period and compares it with the 40-year average (in parentheses): June—5.91 (5.51); July—8.85 (6.16); August—3.50 (5.67); September —19.33 (4.91). The rainfall for September 1945 exceeded the average for June, July and August combined. Approximately nine inches were recorded on September 3, 4 and 5 and again on September 16 and 17. The latter rains were accompanied by winds of hurricane velocity.

Intensive mosquito control operations were in progress during the collecting period and had been under way for more than a year previously.

Table 1.—Collections from 10 diurnal resting stations, June through September, 1945.

Month No. of Visits	June 20	July 27	Aug. 40	Sept. 40	Total 127
Aëdes taeniorhynchus	11	49	58	61	179
Culex quinquefaciatus	43	33	50	40	166
Anopheles bradleyi	12	3	10	11	36
Anopheles quadrimaculatus	10	11	11	2	34
Culex nigripalpus	16	0	0	0	16
Culex (Melanconion)	0	1	5	6	12
Psorophora ciliata	0	0	1	3	4
Aëdes sollicitans	0	1	1	1	3
Culex salinarius	1	0	0	2	3
Culiseta melanura	0	0	0	3	3
Psorophora feroz	2	0	0	0	2
Culex apicalis	1	1	0	0	2
Aëdes atlanticus	0	0	0	2	2
Aëdes infirmatus	0	0	0	1	1
Total	96	99	136	132	463
Av. no. per visit	5	4	3	3	4

The adult population was measured from June through September by establishing 10 diurnal collecting stations. Large flour barrels were placed in the field in situations considered to provide favorable shelter for *Anopheles quadrimaculatus*. At weekly intervals all mosquitoes resting in the barrels were collected in the morning and the number of individuals of each species recorded.

During August and September two workers made the collections. One of these collected all biting mosquitoes during a 5-minute period at the site of each barrel.

In both barrel and biting collections, the records for all stations are combined for the sake of brevity. All station data were at roughly corresponding levels, and their individual populations could be of only purely local concern.

The entire Island was surveyed weekly for larval breeding. Samples were taken from each distinct habitat and descriptive data recorded. Only species, not number of individuals, were recorded.

The following species were recorded during the summer of 1945: *Aëdes: atlanticus* (LDB,[1] *A. infirmatus* (LDB), *A. mitchellae* (L), *A. sollicitans* (LDB), *A. taeniorhynchus* (LDB), *A. triseriatus* (LB); *A. vexans* (L); *Anopheles bradleyi* (LD), *A. quadrimaculatus* (LD); *Culex: apicalis* (D), *C. erraticus* (L), *C. nigripalpus* (LD), *C. pilosus* (L), *C. quinquefaciatus* (LDB), *C. salinarius* (LD); *Orthopodomyia signifera* (L); *Psorophora ciliata* (LDB), *P. confinnis* (LB), *P. ferox* (LDB), *P. howardii* (L), *P. cyanescens* (L); *Culiseta melanura* (LD).

October records added *Anopheles crucians* (L.) and *Uranotaenia lowii* (L.) to the species list, and added a biting record for *Aëdes mitchellae* and *A. vexans*.

The following were collected during the winter of 1944–45: *Aëdes canadensis* (L), *Culex restuans* (L), *Culiseta inornata* (L).

Middlekauff & Carpenter (1944) recorded 49 species from the state. It is interesting to note that this study of an isolated coastal island of about 8000 acres records 27 species or more than one half of the state total.

Table 1 summarizes the data obtained from ten resting stations from June through September.

a. The average total number of mosquitoes per visit was five in June, four in July, and three in both August and September.
b. For practical purposes *Aëdes taeniorhynchus*, *Culex quinquefaciatus*, *Anopheles bradleyi*, and *Anopheles quadrimaculatus* were the only species recorded in significant numbers from the barrels.

The table below compares Parris Island records of the average number of *Anopheles quadrimaculatus* per collection from diurnal stations with those of the southeastern United States (Carpenter 1944).

	June	July	Aug.	Sept.
Parris Island (1945)	.50	.40	.27	.05
S.E. U.S. (1944)	1.34	1.16	0.93	0.85

It is readily noted that the density of *Anopheles quadrimaculatus* for Parris Island is significantly lower than the density for the southeastern United States. Both areas showed a corresponding and regular rate of decrease from June through September.

Table 2.—Biting records from 10 stations. August and September, 1945.

Month No. of Visits	Aug. 38	Sept. 40	Total 78	Av. per Visit
Aëdes taeniorhynchus	159	271	430	5.51
Aëdes sollicitans	2	29	31	.40
Psorophora ciliata	2	17	19	.24
Aëdes atlanticus	0	4	4	.05
Culex quinquefaciatus	1	3	4	.05
Psorophora feroz	1	1	2	.03
Psorophora confinnis	0	1	1	.01
Aëdes informatus	0	1	1	.01
Culiseta (Melanconion)	0	1	1	.01
Culex salinarius	1	1	1	.01
Total	165	329	494	
Av. no. per visit	4	8	6	

Table 2 lists biting records from ten stations during August and September.

a. For practical purposes the only biting mosquitoes were *Aëdes taeniorhynchus*, *A. sollicitans*, and *Psorophora ciliata*. Of these, *A. taeniorhynchus* was by far the most important pest mosquito since its average density was approximately seven times as great as all other biting mosquitoes combined.
b. The average number of all biting mosquitoes per visit in September (8) doubled the August record (4). The increase was due primarily to an increase in *Aëdes sollicitans* (.05 in August; 0.7 in September) and *Psorophora ciliata* (.05 in August; 0.4 in September).

Table 3 records larval collections by species and habitat for the period June through September. It may be noted that:

a. The most productive single habitat was temporary surface water which yielded 45 per cent of the total collections.
b. The most common breeding mosquito was *Aëdes taeniorhynchus* which was present in 30

[1] L represents Larvae; D, Diurnal; B, Biting.

Table 3.—Larval collections. June through September, 1945.

	Surface Water	Pot Hole	Ditch	Marsh	Art. Cont.	Tree Hole	Total	Per Cent Occurrence[1]
No. collections	61	17	24	8	17	7	134	
Per cent of total	45	13	18	6	13	5	100	
Aëdes taeniorhynchus	20	7	7	6	0	0	40	30
Aëdes sollicitans	13	1	10	5	0	0	29	22
Culex quinquefaciatus	10	0	5	0	13	0	28	21
Psorophora confinnis	7	6	2	3	0	0	18	13
Psorophora ciliata	4	5	0	2	0	0	11	8
Aëdes vexans	4	3	1	1	0	0	9	7
Anopheles bradleyi	3	1	1	0	3	0	8	6
Anopheles triseriatus	0	0	0	0	0	6	6	4
Culex salinarius	2	0	1	0	1	0	4	3
Aëdes mitchellae	3	0	0	0	0	0	3	2
Anopheles quadrimaculatus	1	0	0	0	1	0	2	1
Orthopodomyia signifera	0	0	0	0	0	2	2	1
Aëdes atlanticus	0	1	0	0	0	0	1	—
Culex nigripalpus	0	1	0	0	0	0	1	—
Culex pilosus	0	0	0	1	0	0	1	—
Culex erraticus	0	1	0	0	0	0	1	—
Psorophora howardii	1	0	0	0	0	0	1	—
Psorophora cyanescens	0	1	0	0	0	0	1	—
Culiseta melanura	0	0	0	0	1	0	1	—

[1] Per cent Occurrence—obtained by dividing number of collections of the particular species by the total number of collections.

per cent of the collections. Other frequently occurring species were *A. sollicitans* 23 per cent, and *Culex quinquefaciatus* 21 per cent.

c. *Anopheles* breeding was very limited. *A. bradleyi* occurred in 6 per cent of the collections and *A. quadrimaculatus* in only 1 per cent. It is interesting to note that three *A. bradleyi* collections and one *A. quadrimaculatus* collection were from artificial containers.

Table 3 fails to convey the true extent of potential larval habitats. Approximately all parts of the Island not subject to direct tidal action afforded potential breeding sites. Innumerable, small, often minute, water-holding depressions are to be found with little or no search after every rain.

Because of the lack of density data, these records do not convey the correct impression regarding the magnitude of *Aëdes taeniorhynchus* breeding. After every significant rain nearly all surface water produces this species in almost unbelievable numbers. At one time an attempt to measure density in one small area by average number per dip was soon found impossible, and it was then found that approximately one specimen was obtained in every cubic centimeter of water.

SUMMARY.—1. Seven genera and 28 species were recorded.

2. *Aëdes taeniorhynchus, Culex quinquefaciatus, Aëdes sollicitans* and *Psorophora ciliata* were the most common adult mosquitoes based on both diurnal and biting records.

3. *Anopheles quadrimaculatus* occurred at a density significantly lower than the general figure for the southeastern United States. Its density decreased with the progress of the summer.

4. Temporary surface water was the most productive larval habitat. The most common breeding mosquitoes were *Aëdes taeniorhynchus, A. sollicitans,* and *Culex quinquefaciatus. Anopheles* breeding was insignificant.—12-10-45.

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DDT and Hornfly Populations[1]

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In the course of some tests with DDT for the control of flies in dairy and other barns on the farms of the West Virginia Agricultural Experiment Station at Morgantown during the summer of 1945, there was opportunity for a limited test of the material for control of hornflies in pastures.

Tests were made with a herd of 65 heifers kept on pasture through the summer but fed daily in a detached barn which was situated a half mile or farther from other barns where numbers of animals were kept.

These animals were sprayed on July 11, after a considerable hornfly population had developed. Rough counts and estimates indicated that, during the afternoon hours, not fewer than 500 flies per animal were present. Probably the number was somewhat larger than this; certainly on many individuals there were, at time, at least a thousand flies. Even this number is not large when compared with infestations farther south and west but it approaches the usual maximum for the locality.

[1] Published with the approval of the Director of the West Virginia Agricultural Experiment Station as Scientific Paper No. 352.

The DDT was a water-miscible preparation of 40 per cent strength and was diluted to a strength of 2 pounds actual DDT to 100 gallons of water. The treatment was applied with an orchard sprayer which delivered the spray at a pressure of 250 pounds or more. A short extension rod with a bordeaux nozzle attached at an angle was used for the spraying. The animals were sprayed in the feeding stalls. The nozzle was run along one side to the neck of the animal, over the neck and back along the opposite side. The bases of the ears and tops of the heads of the animals received some spray but the faces were not sprayed and no attempt was made to spray the undersides.

The experiment was for the purpose of determining the effectiveness of the DDT without consideration of costs so not attempt was made to determine the exact quantity of material used. The coats of the animals, where they were sprayed, were saturated and it is estimated that more than a half-gallon of spray was used for each animal.

The treatment was applied in the morning; in the afternoon of the same day the hornflies were conspicuous by their absence and few flies of any kind were seen on the animals. Only the one treatment was given but the hornfly population did not reestablish itself during the season. In late September and early October the average number of flies per animal was certainly not greater than 20. Other flies were present but even they were in greatly reduced numbers, as compared with the numbers seen on other farms of the station, not more than a mile away.

DISCUSSION.—Results reported from other localities have been similar to those obtained in this test except for the persistence of the effect which was apparently considerably more prolonged here than it has been reported to be elesewhere. From the South and the Southwest reports have indicated that several treatments may be necessary to give satisfactory control of hornfly throughout the season.

It may be of interest to consider the possible reasons for the more prolonged period of effectiveness indicated here. It is possible that the treatment under discussion was more thorough than others; the high pressure at which the spray was applied, as has been stated, saturated the hair and reached the skin. Even with the rather low concentration of DDT this certainly gave a rather high deposit of the DDT on the hair and even the skin of the animals which would require a longer period of weathering for its removal than lighter treatments which covered only the surface of the coat of the animal.

Weather during the summer was rather favorable for persistence; rainfall was not excessive and there were no heavy storms. The animals had access to shelter, both barns and wooded areas and doubtless protected themselves from the heaviest rains.

However, it is suggested that still another factor was more important than the ones mentioned. The area in question is hilly, partly wooded, pastures are discontinuous and between them are fairly effective natural barriers to migration of the flies. And farm animals are not numerous. The commercial dairies are well scattered and the nearest one to the pasture in question, that of the experiment station dairy, was thoroughly sprayed with DDT—barns, sheds, manure pits, and in August even the dairy herd itself. Other herds were several miles away. The area is semi-suburban and very few farm animals other than those belonging to the experiment station are present. And, we repeat, the topography is such as to discourage migration of the flies.

It seems probable that the treatment applied practically exterminated the local population of hornflies and that migration from other populations was not extensive enough to permit the reestablishment of an infestation.

It may be concluded from this that DDT, applied only once during the season, may afford sufficient protection against hornflies in many localities, especially in the northeastern states, even though such treatment might be inadequate in regions where topography and animal population furnish conditions more favorable to the restoration of the fly populations. And a further point should be noted—that apparent resistance to toxicity of the DDT to hornflies may not be that at all but, rather, the result of early extermination of the local population. —11-19-46.

DDT to Control the Winter Horse Tick

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The winter horse tick, *Dermacentor nigrolineatus* (Pack.), is one of the major external parasites of horses over a wide area in the United States. As its name implies, this tick is most active during cold weather. In Texas on the Edwards Plateau it appears on animals in November and may be found on them until about the middle of March, the peak of population being reached in December or January.

Horses seriously infested with these ticks may suffer from "tick poisoning" or "water belly." Such animals show a general run-down condition, with loss of spirit and appetite. The hair is long and rough and without its normal luster. Swelling occurs under the jaws, along the throat, brisket, and under the belly, extending back as far as the flanks. When the advanced stage is reached, death may result unless the parasites are removed and the horse given special food and care.

The winter horse tick also attacks cattle in great numbers, causing considerable injury to young calves. It undoubtedly contributes to winter losses of cattle, especially during severe winters.

EXPERIMENTAL DATA.—During the winter of 1943–44 preliminary tests were conducted to determine the effectiveness of washes containing DDT for the control of the winter horse tick. Washes of various concentrations were prepared by diluting a stock concentrate (No. 1235) containing DDT and a soluble pine oil. A wash containing 0.4 per cent of DDT was found to give 100 per cent kill, but only limited protection from reinfestation. With a wash containing 0.8 per cent of DDT the animals were protected for a much longer time.

During the tick season of 1944–45 eleven experiments using 175 horses were conducted. Only ranches where severe tick infestations existed were selected for these tests. Animals ranging from young colts to aged animals were represented. The group included work horses, saddle horses, brood mares, and stallions many of which were wild and unbroken and resisted treatment to the utmost.

All the animals were treated by sponging with a wash containing approximately 0.8 per cent of DDT. The head of each horse was left untreated to serve

as a check. In all cases ticks continued to attach and feed on the untreated heads of the horses, showing that ticks were present and that the treatment was affording protection.

One week after the treatment 83.5 per cent of the horses treated were free of ticks, 16 per cent had a few ticks, and 0.5 per cent were still heavily infested. Although these figures do not give an entirely true picture of the efficiency of the wash, they do emphasize the need for a thorough application. In several instances where a few live ticks were found at the first examination after treatment, it was apparent that small areas had not been thoroughly wetted. Many of the experimental animals resisted the treatment to such an extent that a thorough application was almost impossible. However, in one test in which 15 gentle saddle horses were treated only 1 live tick was found 7 days after treatment. The tests clearly demonstrate that this wash is capable of killing all the winter horse ticks on an animal if care is taken to insure complete wetting.

Some animals that had a few ticks on them when first examined were entirely free at the second examination and remained free for a considerable period. Only 3 of the horses required 2 retreatments to keep them relatively free of ticks throughout the season. A total of 68 retreatments was required to protect the entire group of experimental animals from serious reinfestation. Of the horses treated 26 per cent remained free of ticks through the entire season following the initial treatment, 36 per cent became lightly reinfested but required no further application of the insecticide, and 38 per cent required retreatment.

The average period the 175 horses treated were protected from reinfestation was 45 days. Again, these data do not show the true performance of this material, since the pressing demands of other work made it impossible to make examinations at more frequent intervals than 2 weeks. If an animal was infested with nymphs or larvae at a given examination, 2 weeks were subtracted from the protection period reported.

During these tests no harmful effects were noted on the hair or skin of any of the treated animals. It was often noted, particularly in horses with long hair, that nymphs would be present at one observation and the animals would be free of ticks at the next period. This may indicate a residual effect of the DDT on the newly emerged adults. Furthermore, cast skins were sometimes observed on the hair when no live ticks could be found, although dead ones were in evidence.

Many of the horses treated in these tests were ridden immediately after treatment, while others were ridden occasionally during the test period. The odor of the wash was always in evidence, especially when the animals became hot, but no ill effects were observed. Some of the horses that were ridden steadily became reinfested and had to be retreated, while others remained free of ticks throughout the period of the test.

From these experiments it is evident that horses sponged twice during the tick season with a wash made from stock concentrate No. 1235 containing 0.8 per cent of DDT will be protected from the winter horse tick. To obtain satisfactory results the wash should be prepared and applied as described below.

PREPARATION OF STOCK EMULSION AND WASH.—The stock concentrate No. 1235 is prepared by placing 1 part (by weight) of DDT and 5 parts of a soluble pine oil in a tight container and shaking vigorously until the DDT is dissolved. If the container is set in warm water, the time required for the DDT to dissolve will be greatly shortened. This solution is stable under ordinary conditions but at very low temperatures a small amount of DDT will appear in the bottom of the container. When the solution is brought back to room temperature, the DDT will dissolve.

The wash is prepared by adding this stock concentrate to water and stirring gently until a uniform mixture is obtained. In cool weather it is advisable to warm the water to avoid chilling the animal. Six fluid ounces of the stock concentrate in 1 gallon of water gives a wash containing approximately 0.8 per cent of DDT, the suggested treatment.

METHOD OF APPLICATION.—The wash is best applied to the animal with a sponge. The sponge should be partly filled by dipping it into the wash and then applied immediately to the animal. To insure thorough wetting of all hair and skin, the sponge should be rubbed against the lay of the hair. It is often necessary to treat the same area several times before all the hairs are wet. Care must be exercised to be sure that the entire body of the animal is thoroughly treated. Poor application is the principal cause of incomplete control of the horse tick. Some horses can be wetted with 2 quarts of the wash, whereas others may require as much as 2 gallons, depending upon length of hair, type of hair, skin condition, and size of animal.

Large numbers of animals may be run through a chute and sprayed by means of a power-operated sprayer.

CAUTION.—In preparing the stock emulsion one should be careful to wash thoroughly with soap and water the hands, or other parts of the body coming in contact with the liquid, to avoid possible injury from DDT poisoning.—12-30-45.

Sulfur As An Aphicide[1]

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Sulfur has been used extensively as a dust on cotton for control of the cotton fleahopper for approximately 20 years. Also it is used for control of the common red spider on cotton. Usually it is applied in combination with calcium arsenate. Its effect on the cotton aphid, *Aphis gossypii*, which often appears in outbreak numbers following dusting with calcium arsenate, has received relatively little attention, at least relatively little considering the amount used. Fewer aphids have been reported, however, by Ewing & McGarr (1938), Rainwater & Bondy (1941) and McGarr & Henry (1943) on some plots dusted with mixtures including sulfur. Nevertheless, their results were not all consistent and records of others have not shown a lower aphid population on plots dusted with sulfur-calcium arsenate than with calcium arsenate alone. Yarwood (1943) also found that sulfur had value in reducing the numbers of aphids, *Phorodon humuli*, on hops.

In general the experience of the senior writer, prior to 1942, has been in agreement with the com-

[1] Research paper No. 808 Journal series, University of Arkansas, published with the approval of the Director of the Arkansas Agricultural Experiment Station.

mon experience that sulfur-calcium arsenate mixtures applied for boll weevil control have not prevented aphid outbreaks. Sulfur and sulfur mixtures[2] were found to be effective, however, in reducing the numbers of cotton aphids when dust was applied to the under surface of the cotton foliage where most of the aphids feed (Isely 1945). This result was secured in experiments by setting the duster nozzles so low that the insecticide could be blown upward through the plants. When the duster nozzles are carried over the plants, as is usual in boll weevil control, relatively little of the insecticide is deposited on the under surface of the leaves. It was found that to be effective, enough sulfur must come in contact with the aphids to be obvious. Sulfur has no marked fuming action, like that of nicotine. The action of sulfur is relatively slow, and may continue for as long as seven days after application.

These observations are based on experiments during three seasons, 1942, 1944 and 1945, involving 16 replications, where sulfur, and dust mixtures including sulfur, were applied on the undersides of cotton foliage. The dust was applied with a rotary hand duster at a rate varying from about 15 pounds to the acre on relatively small cotton to 30 pounds to the acre on rank cotton. One to four applications were made. On five plots where three and four applications were made, the average infestation was less than 1 per cent of the check. Where only one application was made in field experiments the average infestation was 48 per cent of the check. The average aphid population of all plots was reduced to 5.81 per cent of the average of the checks.

The practical usefulness of sulfur in the control of the cotton aphid will depend upon more extensive field work to determine how sulfur in the dust mixture and a different manner of application will affect the control of other cotton insects.

An opportunity to test sulfur as an aphidicide against the pea aphid[3] was offered in late May and early June of 1945. This did not involve commercial dusting but work in garden plots. A total of five pairs of dusted and undusted plots were included in the experiments. All applications were made with a plunger duster and only a single application was made on each plot. With this manner of application it was relatively easy to be sure that the under surface of the foliage was well covered. In comparison with cotton plants, pea vines are small and easy to cover with dust. During the period covered by these experiments the temperature was relatively high, the mean being approximately 74° F. On each plot the record leaves were tagged and the aphids on these leaves were counted before dusting. Final records of the number of aphids on the same leaves were made two to four days after the application was made.

As in the case of the cotton aphid sulfur was effective in killing only those aphids with which it came in actual contact. The average number of aphids on all five plots, when the final counts were made after dusting, was 32.30 per cent of the population before dusting. During the same period the number of aphids on the undusted checks increased to the extent that the population was actually 123.40 per cent of that when the first counts were made. Assuming a similar potential rate of increase in the sulfur plots, dusting lowered the population to 26.18 per cent of what it would otherwise have been.

In field experiments with the turnip aphid[4] on mustard in November, 1945, dust applications of sulfur did not produce control that could be readily observed. This was partly because of the difficulty in hitting all of the leaf surface where the aphids were feeding. The variety of mustard in these experiments, Giant Southern Curled, affords unusual protection to aphids from dust. On the other hand the population of this aphid was reduced in the greenhouse by a single sulfur application on Shogoin turnips, a variety with relatively smooth upright leaves which were readily covered with dust. Relatively low temperature was also a factor in the field experiments since many aphids lived for some time on leaf surfaces that were heavily dusted. The daily mean temperature for the four days following dusting was not above 60° F. In the second instance the mean temperature was about 72° F.

Following the single application in the greenhouse the aphid population on dusted turnip foliage was reduced to 54.15 per cent of that previous to dusting, while the population on the checks increased 215.51 per cent. If the two series are compared the population on the undusted leaves was only 25.13 per cent of that of the checks. The manner of taking population records of the turnip aphid was the same as for the two species previously discussed; that is, aphids were counted on numbered leaves just before dusting and again four days after dusting.

CONCLUSIONS.—Sulfur is effective as a contact insecticide against a number of species of aphids. Its usefulness is yet to be determined by further experiments. Its effectiveness seems to be dependent upon obvious contact with the aphids and upon a temperature of near 70° F. or higher. It is relatively slow in action. In addition to its possible use as a primary insecticide, sulfur might well be more generally recommended as a diluent for other insecticides. Its cost is sufficiently low for this purpose. Since sulfur has toxic properties of its own, it may add to the efficiency of the mixture, and in some instances may also lengthen the period of effectiveness. When sulfur is used in experimental work as a diluent for other insecticides its aphidicidal properties should not be overlooked when the final results are evaluated.

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[2] Credit is due to the Stauffer Chemical Company for supplying most of the sulfur and other dusting materials used in these experiments.

[3] *Macrosiphum pisi* (Kltb.)

[4] *Rhopalosiphum pseudobrassicae* (Davis).

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Cooperacion Entre los Estados Unidos de Norteamerica y la Republica de Mexico, Para el Control del Gusano Rosado del Algodonero.

Desde el año de 1943 fué formalizada una situación que había venido sosteniéndose desde muchos años antes entre el personal destinado al control del Gusano Rosado del Algodonero, en los Estados Unidos de Norteamérica y los Estados Unidos Mexicanos, con sólo la amistad y el mutuo interés, que fueron formándose entre hombres que trabajan en el mismo problema, en zonas cercanas, a ambos lados de la frontera que limita a nuestros paises.

Esta cooperación entre personas de distinta raza, que hablan lenguas diferentes, con costumbres desiguales, ha venido practicándose al través del tiempo, sobre bases de amistad, de esfuerzo aunado; como bello ejemplo para otros fines y como negación a ciertas políticas internacionales que obran o planean en contrario, en cualquier aspecto de la vida de los pueblos.

En el caso particular que nos ocupa, los resultados de los esfuerzos cooperativos verificados ya sea en forma oficial o extraoficialmente, han venido demostrando año trasaño la bondad del Programa para el Control del Gusano Rosado en el que cooperan nuestros dos paises, si se considera que es y ha sido de resultados benéficos para ambas naciones, en particular para nuestros agricultores, además de esencialmente efectivo para el control y, a veces, erradicación de la plaga.

La confianza mutua convertida en amistad, el deseo de resolver los problemas de trabajo uniéndose, el respeto mutuo y la comprensión paulatina, que borra diferencias; han dado lugar a que el trabajo de los personales americano y mexicano se verifique como si no existiera la línea fronteriza entre los dos paises, sin incidentes o problemas, que no hubieran sido resueltos con beneplácito para todos.

La cooperación propiamente dicha, en lo que respecta al control del Gusano Rosado, se remonta en sus principios al año de 1920, cuando se inició un intercambio de información, una consulta bilateral, entre los empleados de ambos paises interesados en ese objeto. Esta ayuda mutua fué convirtiéndose en amistad y así fué lográndose una cordinación de esfuerzos y simultaneidad de medidas de control, que dejaron entrever la posibilidad de resultados mejores en el control de la plaga que nos ocupa.

En fechas posteriores, esa cooperación fué extendiéndose a otras áreas, a veces con carácter formalizado por los Gobiernos, siempre demostrando con hechos los beneficios que se logran al unificar el criterio de los personales dedicados al control del Gusano Rosado en ambos paises, mediante el intercambio de ideas, planes de campaña y observaciones que poco a poco fueron completando una base para las leyes cuarentenarias que ahora nos permiten laborar con exito en el problema común, a ambos lados del Río Bravo; mejor sería decir, que estas disposiciones legales permiten con mayor libertad, una vigilancia, una supervisión y guía de los trabajos de control que llevan a cabo los agricultores, los propietarios de despepitadores, de vehículos de transporte, etc., en un franco deseo de mejoramiento, reconociendo en su mayoría el beneficio extraído de las prácticas implantadas.

Ya me permití esbozar que el Programa de Cooperación beneficia a los dos paises, y ahora menciono algunas de las razones de esa afirmación. La industria algodonera norteaméricana es varias veces más extensa que la nuestra; ambas son afectadas por las depredaciones del gusano rosado, insecto que en estado adulto puede moverse a grandes distancias por medios naturales, ajenos a lineas fronterizas y medidas curentenarias; por tanto, un mejor control en cualquiera de los dos Territorios es importante para la dis-

minución de los daños en el otro. Los métodos de control, similares en los Estados Unidos y México, reducen en mucho otros factores biológicos contrarios a la planta del algodonero, como son otras plagas y algunas enfermedades; a la vez, crean en el agricultor hábitos que mejoran sus sistemas de cultivo y además, aumentan la producción y benefician a la industria con fibras de mejor calidad, protegiéndola un tanto de los productos sintéticos. Las sendas áreas no infestadas por éste insecto gozan de una mayor seguridad y con éllo de condiciones casi óptimas para su desarrollo económico. Puede considerarse también que aunque los gastos de cultivo aumentan con el control de esta plaga, a la vez se disminuyen en costo algunos de los factores de la producción y se logran resultados que traen provecho económico.

Existen otras razones más en favor, de las cuales algunas se han bosquejado en párrafos anteriores, que subrayan las excelencias del Programa.

La Cooperacion en si

Con un acuerdo entre los dos paises, celebrado en el año de 1943 mediante un intercambio de notas sostenido por los Secretarios de Agricultura de la Unión Americana y la República de México, se inició formalmente un Programa de Cooperación en el Control del Gusano Rosado del Algodonero.

Dentro de México, el área cultivada con algodonero se ha subdividido en siete zonas de combate o prevención, en cada una de las cuales existe personal de la Oficina Fitosanitaria y de la Oficina de Entomología y Cuarentena de Plantas de Washington, que unen sus conocimientos, esfuerzos y equipo para un mismo fín; unos tratando de proteger la vasta industria algodonera de los Estados Unidos de Norteamérica y los otros, la propia agricultura de su País.

Para esas siete zonas, cuenta la Dirección General de Agricultura con Delegaciones Fitosanitarias que se encargan de todos los trabajos relacionados con las plagas y enfermedades de los cultivos, pero que dedican la mayor parte de su atención al control del Gusano Rosado del Algodonero. A cada una de estas Delegaciones se ha unido un Representante de la Oficina de Entomología y Cuarentena de Plantas, cuyo deber es mantener las relaciones cooperativas en cada lugar.

Como base para los trabajos, se cuenta con los acuerdos entre los dos paises, ciertas reglas dictadas por el uso y con el respeto y confianza mutuas entre los Delegados, su personal y los Agentes Norteamericanos.

Las Leyes Cuarentenarias y Reglamentos que en nuestro País se han dictado para el combate del Gusano Rosado, han sido mejorados paulatinamente desde hace muchos años y en la actualidad la inmensa mayoría de los problemas se resuelven con la cooperación decidida de los sectores unidos al cultivo del algodón, condición que ha sido obtenida por medio del convencimiento, que es fruto de una labor educativa sostenida, de la simpatía y amistad entre el sector oficial y el agrícola, que ahora hacen casi innecesario el uso de las sanciones que las leyes fijan.

Los Representantes de la Oficina de Entomoligía y Cuarentenas de Plantas cuentan con personal pagado por el Gobierno Norteaméricano y équipo de transporte, que laboran permanente o temporalmente bajo las órdenes directas del Delegado Fitosanitario. Por la complejidad del problema, ya que en él entran en juego tantos factores, es difícil valorizar monetariamente la cooperación y sólo puedo usar de los datos que bondadosamente me han sido facilitados por los señores R. E. McDonald y D. M. McEachern de la División de Control del Gusano Rosado, para dar idea de su monto.

El personal y équipo ha consistido de lo siguiente:

Meses		Personal Permanente	Personal Temporal	Automoviles
Julio	1943	11	20	32
Agosto	"	11	39	35
Septiembre	"	11	39	35
Octubre	"	11	45	41
Noviembre	"	12	44	42
Diciembre	"	12	47	42
Enero	1944	12	42	44
Febrero	"	12	46	43
Marzo	"	12	44	43
Abril	"	12	41	41
Mayo	"	12	34	32
Junio	"	13	23	31

El personal temporal, puede haber sido pagado por unos cuantos días, por semanas o meses, siendo según su permanencia el uso que se le dá al equipo de automoviles.

Del personal, tanto permanente como temporal, hemos recibido sugestiones y

enseñanza que han sido de gran ayuda para la campaña contra esta plaga, además de que han venido trabajando de consuno con el personal de las Delegaciones Fitosanitarias, personal que consiste en su mayoría de Agrónomos especializados que actúan como Delegado y Jefes de Zona, además del personal de campo que es pagado por el Gobierno Mexicano.

No hay que olvidar que en México tanto los agricultores como otras personas interesadas, contribuyen substancialmente al logro de los trabajos y así tenemos que en el año de 1943 se hace una estimación del valor en metálico con que estos sectores contribuyen, dando un total de 7.051,169.00 dólares que al tipo de cambio de 4.85 dólar, dá 34.196,165.65 pesos.

La cooperación que dá el personal americano es de gran valor en la vigilancia de la esterilización de la semilla, quema de desperdicios de despepitador, limpieza de los puntos de concentración, limpieza de los campos, incineración de tallos, barbecho de las tierras, prevención del "retoño" y "soca," control de siembras y en general en todas las medidas usadas contra el Gusano Rosado, repartiendo su atención sobre una superficie que durante el año de 1944 se calcula estimativamente en 285,000 hectáreas sembradas con algodón, diseminadas sobre gran parte del territorio norte de la Republica. Además, cooperan en las reuniones que se verifican con los agricultores más destacados en cada zona, en las cuales se discuten aquellos asuntos que tienen nexos con el control del Gusano Rosado y se exhiben películas educativas sobre la plaga y los métodos de control que se utilizan contra ella; colaboran también en el programa educacional, que principia enseñando a los Inspectores los principios en que se basan las medidas de control, para que ellos a su turno den esa información directamente a los agricultores.

En reuniones que se efectúan una o varias ocasiones en el año, los Representantes Norteaméricanos y los Delegados, con la presencia de las Autoridades Superiores de México, cambian impresiones, experiencias y discuten con amplitud y libertad los problemas propios de cada zona, aunando sus criterios para resolverlos, sin diferencias de ninguna clase, con una camaradería respetuosa.

Un ejemplo es la última Reunión celebrada en la Ciudad de Monterrey, N. L., durante los días 12, 13 y 14 de Noviembre del presente año. Se discutieron en élla puntos de suma importancia, buscando solución a problemas, tratando de mejorar ciertos aspectos de la Campaña, dando a conocer las experiencias favorables o desfavorables en cada zona, etc. El éxito de la reunión fué completo.

Asistieron a ésta Junta:

De la Direccion General de Agricultura

Ing. Darío L. Arrieta M.—Director General.
Ing. Ricardo Coronado Padilla, Jefe de la Oficina Fitosanitaria.
Ing. Luis Cortés Gómez, Jefe de la Sección de Campañas de la Oficina Fitosanitaria.
Ing. Manuel Alcazar Cerda, Delegado Fitosanitario en Ciudad Juárez, Chih.
Ing. Alfonso Delgado de Garay, Delegado Fitosanitario en Matamoros, Tamps.
Ing. Adolfo Lara Sandoval, Delegado Fitosanitario en Monterrey, N.L.
Ing. Carlos Sanders Bermudez, Delegado Fitosanitario en Ciudad Delicias, Chih.
Ing. Guillermo Torres Cordera, Delegado Fitosanitario en Torreón, Coah.
Ing. José Rodríguez Galicia, Delegado Fitosanitario en Saltillo, Coah.
Santiago J. Rodríguez, Delegado Fitosanitario en Ojinaga, Chih.
Eduardo Garza López, Jefe de Zona Fitosanitaria, dependiente de la Delegación en Torreón, Coah.
Ing. Fermín Villalva Camou, Jefe de Zona Fitosanitaria dependiente de la Delegación en Monterrey, N.L.

De los Estados Unidos de Norteamerica

L.F. Curl, Jefe de la División, División de Control del Gusano Rosado.
R.E. McDonald, Jefe del personal de Cooperación, Monterrey, N.L.
D.M. McEachern, Representante en Matamoros, Tamps.
R.P. Barreda, Ayudante del Representante en Matamoros, Tamps.
J.C. Bateman, Representante en Monterrey, N.L.
D.H. Currie, Representante en Torreón, Coah.
J.C. Gay, Representante en Cd. Delicias, Chih.
B.R. Stephens, Representante en Cd. Juárez, Chih.
L.D. Harris, Representante Ojinaga, Chih., radicado en Alpine, Tex.
J.A. Alderdice, Texas State, Department of Agriculture, Austin, Tex.

Resultados

Los frutos de esta cooperación, interpretados por la presencia del Gusano Rosado, son excelentes. Las infestaciones se han disminuído, se han conservado constantes o por factores naturales fuera de control, han aumentado en algunas

zonas, sin que en las regiones de que se ha erradicado la plaga o donde no ha existido núnca, se hallen sufrido sus daños a la fecha. Como confirmación, existen dos zonas en el área cuarentenada de este País, que han sido liberadas de la plaga desde que se inició la Cooperación internacional, ya que en ellas no se ha encontrado Gusano Rosado durante los últimos cuatro o cinco años. Ellas son: El área de Don Martín, en el Estado de Nuevo León, donde se cultivan de 15,000 a 20,000 hectáreas de algodón anualmente y la porción norte del Estado de Coahuila donde se siembran con algodón de 4,000 a 6,000 hectáreas cada año. Por medio de los métodos de control que ya he mencionado, se ha logrado la erradicación total del Gusano Rosado en esas grandes regiones.

Por todo lo aquí asentado, puede considerarse que esa cooperación, madurada a través de varios lustros, es ahora una bella realidad que, bajo los auspicios que se asienta llegará a ser más perfecta, con resultados más halagadores cada día, con mayores beneficios para nuestros dos paises, siempre llevada bajo principios de respeto y amistad recíprocos, perfeccionándose.

Sólo me resta agradecer a ustedes su atención y suplicarles perdonen las repeticiones en que pueda haber incurrido, así como la brevedad de este reporte, que sólo quiere ser un breve pero fiel retrato de lo que es el Programa de Cooperación México-Americano en el control del Gusano Rosado.

H. Matamoros, Tamps., a 1/o de Dic. de 1945.

ING. ALFONSO DELGADO DE GARAY

The above article by Señor Delgado de Garay is the first contribution made by any of our Mexican colleagues to our programs or our JOURNAL. It is printed as written, in Spanish, because this language is read by many of our members and because the author's presentation of his subject matter must be distorted to a degree, in translation. The Mexican colleagues of the author will thus have access to the article and we hope they may take this as an indication of the whole-hearted goodwill of our Association to them and their work and as a further mark of appreciation of this country for the unselfish cooperation afforded through many years by the Mexican Government and the Mexican People in the problems of insect control which have usually been much more vital to us than to them.

Members who desire a translation will be furnished a mimeographed copy on application to the editor.

HORTICULTURAL INSPECTION NOTES

REVISIONS OF FEDERAL PLANT QUARANTINES AND ADMINISTRATIVE INSTRUCTIONS

The Gypsy moth and brown-tail moth quarantine (Quarantine No. 45) was revised effective October 10, 1945, to redefine as "generally infested" the regulated area formerly classified as "lightly" and "generally" infested, thus eliminating the classification of "lightly infested area"; to add to the regulated area part of eastern New York, additional areas of Connecticut and Vermont, and that part of Massachusetts not heretofore included in the regulated area, these additional areas to be known as the "suppressive area"; to redefine the boundary of the area regulated on account of the brown-tail moth; and to prohibit the unauthorized movement of live Gypsy and brown-tail moths in any stage.

The Mexican fruitfly quarantine (Quarantine No. 64) was revised effective November 26, 1945, to provide for eliminating the use of permits for regulated citrus fruits for a part of any year by the Chief of the Bureau of Entomology and Plant Quarantine through administrative instructions.

The white-fringed beetle quarantine (Quarantine No. 72) was again revised effective December 12, 1945, for the purpose of extending the regulated areas to include additional areas in which white-fringed beetle infestations have been located. New counties, parts of which are included for the first time are: Coffee County, Alabama; Bladen, Robeson, and Union Counties, North Carolina. Minor additions to the regulated area were also made in other counties of Alabama, Florida, Mississippi, and North Carolina. This revision also placed under regulation straw, plant crowns or roots for propagation, and uncleaned grass, grain, and legume seed. Effective on the same date the Bureau issued B.E.P.Q., 485, 14th Revision, modifying the certification requirements for regulated articles.

The black stem rust quarantine (Quarantine No. 38) was amended effective February 1, 1946, to add Kansas to the States now being protected under the provisions of that quarantine.

Amendment No. 2 to the pink bollworm quarantine was issued effective February 4, 1946, for the purpose of adding to the lightly infested area the entire Texas counties of Brown, Chambers, Jefferson, Liberty, Medina, Orange. Uvalde, and part of Harris County, Texas.

Oriental Fruit Moth Quarantines Revoked

The following States have revoked their Oriental fruit moth quarantines: *Arizona* (December 20, 1945), *Idaho* (December 7, 1945), *Montana* (August 22, 1945), *Nevada* (January 2, 1946), *Oregon* (October 30, 1945), and *Washington* (December 19, 1945). The State of Colorado modified its Oriental fruit moth quarantine effective January 1, 1946, to add the entire States of California, Idaho, Oregon, and Washington, to the quarantined area. Colorado and Utah are now the only states maintaining Oriental fruit moth quarantines.

Sweetpotato Weevil Quarantines

Effective January 10, 1946, Georgia revised Quarantine No. 3, pertaining to the sweetpotato weevil, to add the following Mississippi counties: Green, Hancock, Harrison, Jackson, Stone, and Walthall, to the regulated area.

Effective January 5, 1946, Louisiana amended its sweetpotato weevil quarantine to include part of West Feliciana Parish.

Effective November 7, 1945, Mississippi revised its sweetpotato weevil quarantine, Rule 24-A, to include all the counties of Baldwin, Mobile, and Washington, Alabama, parts of which were previously under quarantine, and to bring the quarantined area in Texas in line with other standard state quarantines on account of this insect.

Florida Corn Borer Quarantine Revised

The State of Florida issued Special Bulletin No. 3, revising its European Corn Borer Rule, effective November 10, 1945, so as to include the States of Kansas, Minnesota, and Nebraska, the entire States of Iowa and Missouri, only certain counties of which have heretofore been under quarantine, and the counties of Montgomery, Robertson, and Sumner in Tennessee, to provide for the entry of host plants and plant products after treatment, and to provide for the entry of winter-grown greenhouse rhubarb.

Arizona Revises Its Strawberry Root Weevil Quarantine

The Strawberry Root Weevil Quarantine (Quarantine Order No. 10) of Arizona was revised January 25, 1946, to exempt 14 states from the restrictions of this quarantine and to provide for the admission of plants fumigated with methyl bromide.

Phony Peach Quarantine

The State of Missouri revised its Phony Peach Quarantine (Quarantine No. 1) November 23, 1945, and the State of Georgia, its Order No. 1 on account of the same disease January 15, 1946, to conform to the recommendations made by this Bureau after the 1945 annual inspection had been completed.

NOTES

Captain Raymond C. Bushland—An Echo from the Army

The following is quoted from a letter written by Brigadier General S. Bayne-Jones, Director of the American Typhus Commission, Washington, D. C., who submitted a Journal Paper on behalf of Captain Bushland, "Captain Bushland, who is now out of the Army . . . had a long distinguished service with the U. S. A. Typhus Commission, Among the studies he carried out in New Guinea were some investigations of area control of mites. The purpose was to see whether an area could be freed from scrub typhus by destroying mites in the field. A considerable amount of scientific and practical material came out of these studies."

The paper mentioned above deals with these studies and will appear in an early issue of the Journal.

M. D. Leonard Joins the Bureau

Dr. Mortimer D. Leonard, for the past four years in charge of insecticide price controls under the authority of the Office of Price Administration, has joined Dr. Sasscer's staff in the Office of Foreign Plant Quarantines in the Bureau of Entomology and Plant Quarantine.

Dr. Leonard's duties will include the collection and dissemination of information concerning the insects which are likely to be introduced from abroad into the United States.

The many friends of Dr. Leonard will welcome him back into the ranks of professional entomologists, especially in a capacity where his wide knowledge of insects in all groups can be very effectively utilized.

A. M. Vance and W. G. Bradley of the federal Corn Borer Investigations, J. J. Davis of Purdue University, and George C. Decker of the Illinois Natural History Survey, took part in a state-wide conference on the European corn borer, held at Cedar Rapids, Iowa, January 16 and 17, under the direction of C. J. Drake, head of the Entomology Department of Iowa State College.

J. J. Davis, of Purdue, was the guest speaker at the monthly meeting of the Western New York Section of the American Chemical Society, held at the University of Buffalo, February 19. The subject of his talk was *Chemistry and Pest Control.*

J. G. Sanders Now With Commercial Solvents Corporation

Dr. J. G. Sanders has joined the staff of Commercial Solvents, with headquarters in New York City. Dr. Sanders spent much time during the war in several stations in South America and Iran on war activities. He will be concerned with the development and marketing of some of the new insecticides, in his present position.

TWENTY-SECOND CUMBERLAND-SHENANDOAH SPRAY CONFERENCE

The twenty-second annual session of the pioneer regional conference on insect and disease control problems common to several states was held when the Cumberland-Shenandoah Conference held its annual meeting in Winchester, Virginia, on November 23 and 24, 1945.

Dr. W. S. Hough, of Winchester, presided and Dr. S. A. Wingard of Blacksburg served as general secretary of the Conference. As is customary, the horticulturists present conducted their own separate meeting while the Insects and Disease Section discussed problems within their scope of interest. At the end of the programs a final general meeting was held for committee reports and election of officers for the coming year. A. F. Vierheller was elected Chairman and E. A. Walker, Secretary for 1946. Both of these men are from Maryland. E. N. Cory was made Chairman, and Geo. S. Langford, Secretary, of the Committee on Insects and Diseases.

States represented included Delaware, Maryland, New York, North Carolina, Pennsylvania, Virginia and West Virginia as well as the United States Department of Agriculture. Sixty-five members and visitors registered.

Reports covered such subjects as Fungicides, reported by F. H. Lewis, of Arendtsville, Pa., who discussed scab, cedar rust and oil-fungicide compatibility on apples, as well as other subjects including airplane dusting of peaches for control of brown rot. General discussion of disease problems was continued by several members.

Discussion of Insecticide-Fungicide combinations, including several brief reports, gave preliminary information on several new combinations.

Among the reports on work with insecticides may be mentioned a statement by Edwin Gould, of West Virginia, that DDT had given good results, in summer applications, for control of the pistol case case bearer; W. S. Hough reported good results with dinitro compounds for control of the rosy apple aphis and James E. Dewey, of New York reported that 4 per cent paraffin oil, applied not later than the delayed dormant stage, had given best results for control of the apple redbug.

As might be expected, the reports of the work on codling moth control with DDT attracted the greatest interest. The uniformity of the reports tells more than anything else could, of the remarkable results secured and the definite superiority of the DDT over lead arsenate or any other material used, for the control of this primary apple pest. Some information as to the residue problem was presented, in so far as this problem is affected by the addition of DDT to the list of residue-producing materials.

General discussion of several other orchard insects followed the consideration of DDT. The program was concluded by the formulation of the spray-schedule to be recommended for use during the season of 1946. This followed the basic plan of general agreement on the main features of the program to the end that growers receiving information from several sources may not be confused; freedom for the individual workers in different states to adapt details to suit local conditions is, and has been, an essential feature of the concerted program.

TWENTIETH ANNUAL WESTERN CO-OPERATIVE SPRAY CONFERENCE

The Twentieth Annual Conference of the Western Cooperative Spray Project was held at Portland, Oregon, on January 23 and 24. This is an official conference of entomologists, chemists, plant pathologists and horticulturists engaged in state or federal research work on orchard spraying problems in the West. The membership includes men from the experiment stations of California, Idaho, Montana Oregon and Washington, the Bureau of Plant and Insect Control of the Colorado Division of Agriculture, the Canadian Department of Agriculture, and the U. S. Department of Agriculture.

Discussions covered research work on dormant sprays, codling moth, mites, cherry fruit fly, pear thrips, pear psylla, filbert insects, pear scab, and peach leaf curl. The occurrence of the Oriental fruit moth in the West was discussed and the composition of DDT was given special attention.

The annual suggestions for the use of orchard sprays, which is used by some of the states as a basis for their own recommendations, was brought up to date. No recommendations for the use of DDT were made.

The conference adjourned at noon of the second day for a group luncheon with representatives of insecticide manufacturers and distributors, field men of growers' organizations, and horticultural inspectors. Afterwards a joint meeting was held, presided over by Ed Littooy of the *Colloidal Products Corporation*, at which there was a discussion of DDT and of the availability of insecticides and fungicides. There was an attendance of 144 members and visitors at the joint meeting.

The attendance of members of the Spray Project was larger than usual, the following being present:

British Columbia:
- Ben Hoy
- James Marshall
- J. M. McArthur

California:
- A. D. Borden
- A. B. Lemmon

Idaho:
- H. C. Manis
- W. E. Shull

Washington:
- D. F. Allmendinger
- D. H. Brannon
- E. P. Breakey
- L. R. Bryant
- D. J. Crowley
- P. M. Eide
- Kermit Groves
- Folke Johnson
- W. J. O'Neill
- F. L. Overley
- J. C. Snyder

Oregon:
- Leroy Childs
- L. G. Gentner
- S. C. Jones
- C. H. Martin
- Don C. Mote
- R. H. Robinson
- R. G. Rosenstiel
- B. G. Thompson
- S. M. Zeller
- J. L. St. John
- C. L. Vincent
- K. C. Walker
- R. L. Webster

U. S. D. A.:
- F. W. Carlson
- F. P. Dean
- S. M. Dohanian
- K. A. Haines
- J. R. Kienholz
- M. A. Yothers

LEROY CHILDS, *Hood River, Oregon*, was Chairman of the conference.

F. L. OVERLEY, *Secretary*

PROCEEDINGS OF THE FIFTY-SEVENTH ANNUAL MEETING

American Association of Economic Entomologists

Hotel Adolphus, Dallas, Texas, December 3, 4, 5 and 6, 1945

The Dallas meeting, December 3 to 6 inclusive, marked the first gathering of the Association in the Southwest. In every respect, the meeting was a signal success. It was well attended by a group most of whom rarely have an opportunity to attend a national conclave. Close attention was paid to a splendid program. The four day period in place of the usual three days relieved the congestion considerably so that there were few conflicts. The banquet was well managed, the single address interesting and the entertainment had the true "South of the Border" characteristics. E. W. Laake and his assistants deserve great credit for managing the affair with efficiency and graciousness.

The Cotton States Branch and the Texas Entomological Society held their annual business meetings as part of the program. The Presidents of these two organizations were given places of honor on the morning programs and the Secretaries assisted in numerous ways in keeping the meetings running smoothly. Two hundred and forty entomologists were registered.

The morning sessions were devoted to topics of general interest and the afternoons and evenings to submitted titles and sectional meetings. The morning sessions were so outstanding that a complete résumé of the addresses is given herewith:

Monday, December 3—Welcoming Address, S. W. Bilsing, College Station Texas, Cotton States Branch and Texas Entomological Society; Address of the president of the American Association of Economic Entomologists, "Involvements in Present Day Economic Entomology"—D. L. Van Dine; Presidential Address, Cotton States Branch—"Comments on Post War Entomological Problems in the South"—C. E. Smith, Baton Rouge, Louisiana.

Tuesday, December 4—Presidential Address, Texas Entomological Society, N. O. Berry, Harlingen, Texas; "The Insecticide Situation," F. C. Bishopp, Washington, D. C.; "Recent Developments in Cooperative Insect Control Programs," W. L. Popham, Washington, D. C.

Wednesday, December 5—"International Aspects of Pink Bollworm Control"—Ing. Alfonso Delgado de Garay, Member of the Mexican Department of Agriculture; "Cotton Insect Control and Commercial Interests"—Alston Clapp, Sr., Houston, Texas; "Gains Make Profits"—Ray L. Cuff, Kansas City, Missouri.

Thursday, December 6—Discussions on Uses of DDT—For Control of Insects Affecting Man, E. F. Knipling, Orlando, Florida; For Control of Insects on Livestock, W. G. Bruce, Savannah, Georgia; For Control of Household and Stored Products Insects, J. J. Davis, Lafayette, Indiana; For Control of Agricultural Insects, G. E. Carman, Riverside, California; "DDT and Its Effect Upon Wildlife," Clarence Cottam, Fish and Wildlife Service, Department of the Interior.

The participation of Senor Delgado, representing the Mexican Department of Agriculture, inaugurated a practice of inviting our neighbor scientists to participate, which we sincerely hope may become a regular part of the procedure of the Association. In the past our neighbors from the North have taken an active and major part in the conduct of Association affairs, but this is the first time that our Mexican confreres have participated in a national meeting.

Report of the Secretary-Treasurer

Despite war time interruptions, the membership continues to increase. The remittance of dues to men in the service viewed as a gesture of those who had to stay on the job at home has been, I am sure, appreciated by the service men. It has a practical aspect as well; few have discontinued membership; most members have continued to take the Journal. Both of these items are the opposite of what occurred during the first World War. Today we have 1774 members, an increase of 130. There were 6 deaths and 15 resignations and 21 were dropped. The Journal subscribers have increased from 2419 to 2642. Industry, including the Pest Control Operators, is rapidly realizing its dependence upon the Journal for the last word on those things that vitally affect its business.

The most noteworthy advance in Association matters is the formal inclusion of the North Central States Branch. For many years the members of this Branch have been loyal and active. The loosely knit organization has functioned effectively in serving the needs of the area. As a Branch they will continue just as effectively and in addition will help the solidarity and increase the prestige of the parent Association.

The immediate concern of this office is to make the Reemployment and Placement Service function effectively. The Committee consisting of Roger C. Smith, L. M. Peairs and your secretary has devised a questionnaire that has been sent to all members in the armed forces whose addresses are available. Returns that are coming in daily are being transferred to a card system by Miss Margaret Walton, an entomologist with the Production and Marketing Division of the U. S. Department of Agriculture. Employers desiring the services of an entomologist can apply to this committee for assistance and already several employers have been furnished names of prospects. Each employer is sent the names and references of the registrants that most nearly meet his specifications and the registrant is notified by card that his name has been submitted. Strangely enough, some returning entomologists are finding that changing conditions are making return to their old jobs most difficult so that some excellent men are available for new assignments. Employers are urged to avail themselves of the opportunity to get data in regard to the available returned entomologists and any others who for any reason may want to make a change. The small registration fee will not begin to pay the costs of the service, but this Association can well afford to devote the necessary funds to insure reemployment and placement of all entomologists.

The new issue of *Entoma* is being mailed to all members. It is a splendid achievement, reflecting great credit upon George S. Langford, the Editor, and the Committee that worked with him.

We regret that the Entomological Society of America is not meeting with us and it is expected that the circumstances accounting for their absence will not be repeated in the near future. The American Association for the Advancement of Science will not meet this year until March 27, in St. Louis, a date too far removed from our normal meeting date to permit us readily to meet with them. The Executive Committee realizes the advantages of meeting with the AAAS, but also recognizes a responsibility to its membership in the South, Southwest and West, areas distant from the area in which the AAAS normally holds its meetings. We are assured that next year the AAAS will return to the Christmas holiday time of holding its meeting and that at the St. Louis meeting a tentative schedule of meeting places will be worked out. With such a listing, it is quite likely that we can adjust our meeting places so that we can meet with the AAAS at least every other year. The Entomological Society of America is anxious to meet at least every other year with the AAAS and such an arrangement should be satisfactorily to all.

There is need for a comprehensive report on the part that entomology played in the winning of the war. Possibly this is the function of the Committee on Coordination of Entomology with the War Effort. Certainly a permanent record of individual participation in the armed forces, the protection from pests of food, fibre and structures and the work of development of the means for the control of insect vectors of disease and pestiferous arthropods should be prepared, published possibly as a supplement to the JOURNAL and an attempt made to publicize the essential part that entomology as a science and as a service has contributed to the national effort.

The material for Index VII is now ready for typing. The present bottleneck is the unavailability of typists. After typing, it goes to the taxonomists and finally to the Editor, Stanley E. Bromley. Miss Hawes is to be commended for her interest and painstaking care in assembling the essential data. Possibly a change in the period covered by each volume may be necessary and desirable.

The report of the Committee on Common Names emphasizes the need for prompt action in the submission of new names and changes so that a consolidated list may be published. There is a constant demand for the old list, copies of which are no longer available.

It is a pleasure to acknowledge the gift of $500 from Dr. Julius Hyman of the Velsicol Company of Chicago. This gift has been set aside in a separate savings account, as will appear in the Auditor's report, for such use in conformity with the terms of the gift, as the membership may determine.

The Auditor's report is as follows:

EDWARD D. TREMBLY
Certified Public Accountant
College Park, Maryland

November 29, 1945

Dr. E. N. Cory
American Association of Economic Entomologists
College Park, Maryland

Dear Dr. Cory:

I have made an examination of the accounts and financial records of the American Association of Economic Entomologists for the fiscal period December 1, 1944 to November 20, 1945. In connection therewith, I have reviewed the accounting procedures of the Association, and without making a detailed audit of transactions, have examined or tested accounting records of the Association and other supporting evidence, by methods and to the extent deemed appropriate. My examination was made in accordance with generally accepted auditing standards applicable in the circumstances and included all procedures which I considered necessary.

In my opinion, the accompanying statements of receipts and disbursements of the association, the Permanent Fund, and the Special Journal Savings Account present fairly the result of the Association's operations for the fiscal period and the cash position of its funds at November 20, 1945.

Very truly yours,
EDWARD D. TREMBLY
Certified Public Accountant

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

STATEMENT OF RECEIPTS AND DISBURSEMENTS FOR THE FISCAL PERIOD DECEMBER 1, 1944 TO NOVEMBER 20, 1945

	TOTAL	JOURNAL	ASSOCIATION	INDICES I–V	INDEX VI	INDEX VII	INDEX VIII
Receipts:							
Subscriptions	$ 6,419.35	$6,419.35					
Advertising	131.20	131.20					
Reprints	762.80	762.80					
Back Numbers and Miscellaneous	1,214.79	1,214.79					
Dues	2,776.25		$2,082.19			$ 350.50	$343.56
Life Memberships	100.00	100.00					
Sale of Indices	111.60			$ 58.80	$ 52.80		
Bond Interest	50.00		50.00				
Reimbursement of Projection Costs at New York Meeting	17.50		17.50				
Registration-Re-employment Placement Committee	16.00		16.00				
Total Receipts	$11,599.49	$8,628.14	$2,165.69	$ 58.80	$ 52.80	$ 350.50	$343.56
Life Membership Receipts to be transferred to Permanent Fund Savings Account in Prince Georges Bank & Trust Co.	100.00	100.00	0	0	0	0	0
Adjusted Receipts	$11,499.49	$8,528.14	$2,165.69	$ 58.80	$ 52.80	$ 350.50	$343.56
Disbursements:							
Auditing and Accounting Fees[1]	$ 108.00	$ 54.00	$ 54.00				
Surety Bond for Secretary	12.50	6.25	6.25				
Safe Deposit Box Rental	3.60		3.60				
Printing	7,762.80	7,762.80					
Engravings, drafting, etc.	326.48	326.48					
Honorarium, Secretary, Business Manager	600.00	300.00	300.00				
Stenographic and Clerical	517.70	258.85	258.85				

Traveling[2]	509.37		509.37				
Committee Expenses	20.95		20.95				
Branch Expenses:							
Cotton States	102.93		102.93				
Pacific Slope							
North Central States							
Postage, Stationery and Supplies	411.92	205.96	205.96				
Telephone and Telegraph	19.85		19.85				
Express	7.90	7.90					
Refunds	7.35	7.35					
Insurance on Books, Furniture and Equipment ($10.07 Unexpired Insurance as of November 30, 1945)							
Notary Fees	4.50		4.50				
Bank Service Charges	24.29	12.15	12.14				
New York Meeting Expenses, Projection, Badges, and Programs	174.06		174.06				
Total Disbursements	$10,614.20	$8,941.74	$1,672.46	0	0	0	0
Excess of Adjusted Receipts Over Disbursements	$ 885.29	$ 413.60*	$ 493.23	$ 58.80	$ 52.80	$ 350.50	$343.56
Add: Balance November 30, 1944	4,832.45	1,116.37	4,504.18	438.61	2,804.80*	1,578.09	0
Balance November 20, 1945	$ 5,717.74	$ 702.77	$4,997.41	$497.41	$2,752.00*	$1,928.59	$343.56

This Balance is Represented by the Following:	
Prince Georges Bank & Trust Co. (Checking Account)	$ 3,817.74
Less: Amount Due Savings Account for Life Memberships	100.00
	$ 3,717.74
U. S. Defense Bonds, Series G (2½%)	2,000.00
Total (As Above)	$ 5,717.74

[1] Auditing and Accounting Fees: 1944, $43.00; 1945, $65.00.
[2] Traveling. Includes Traveling Expense of President of Cotton States Branch, Secretary, and Business Manager to Dallas.
* Deficit.

STATEMENT OF PERMANENT FUND

Balance, December 1, 1944		$26,354.27
Income for the period:		
Interest received from securities	$236.25	
Interest received from savings deposit	63.15	
Interest credited to book value of U. S. Bonds	600.00	
Life Membership	100.00	
Total Income		999.40
Balance, November 20, 1945		$27,353.67

This balance is invested as follows:	PAR VALUE	BOOK VALUE	
Securities:			
Province of Ontario 5's	$ 2,000.00	$2,000.00	
U. S. Treasury Bonds 2½'s	3,000.00	2,984.00	
U. S. Savings Bonds, Series A	5,000.00	5,000.00	
U. S. Savings Bonds, Series D	10,000.00	8,700.00	
U. S. Defense Bonds, Series G	2,000.00	2,000.00	
Total Securities			$20,684.00
Bank Deposit (Savings Account):			
Prince Georges Bank & Trust Co. (2%)		$6,569.67	
Due from checking account (Life Membership)		100.00	6,669.67
Total Investment in Permanent Fund			$27,353.67

STATEMENT OF SPECIAL JOURNAL SAVINGS ACCOUNT

Receipts:	
Gift—Dr. Julius Hyman of Velsicol Corporation, Chicago, Illinois	$500.00
This balance is represented by:	
Prince Georges Bank & Trust Co. (Savings Account)	$500.00

Most of the business transacted at the Executive Committee meeting is included in minutes of Final Business Session as recommendations, all of which were approved. Items discussed at the Committee Meeting were largely the result of proposals made at the preliminary Business Meeting. Consequently, in order to save space the complete proceedings of the Preliminary Business Meeting are omitted. Items not submitted as recommendations are included in the minutes of the Executive Committee in the files of the Secretary.

REPORT OF FINAL BUSINESS SESSION
December 6, 1945

A. The Executive Committee recommended the following amendments to the Constitution, all of which were passed:

1. Add to Article VI, Section 5, "Balloting by mail for any or all officers or upon any proposal may be authorized by the Executive Committee."
2. Change Article IV, Section 2 to read: "The

President, the retiring President, who shall be a member for two years, the Secretary-Treasurer, the First Vice-President and the Editor of the JOURNAL, together with three active members, one of whom shall be elected each year for a term of three years shall constitute the Executive Committee, whose Chairman shall be the active President."

3. Add to Article III, Section 2 after "Active Members"—"by letters of recommendation, furnishing the background of the applicant,"

4. The following new procedures in the nomination and election of the President and First Vice-President were approved by the Executive Committee and announced so that a ballot may be taken at the next annual meeting on an amendment to the By-Laws to effect the changes: Add to Article II, Section 6 of the By-Laws, "except the President and First Vice-President who shall be nominated and elected as hereinafter provided." "Three months prior to each annual meeting the Secretary shall invite each member of the special Nominating Committee consisting of the First Vice President, the Secretary, the three immediately preceding past Presidents, the three immediately preceding First Vice-Presidents and the Chairman of each of the Branches to select three names for President and three for First Vice-President. These names, arranged alphabetically, for each office shall be submitted to the members by the Secretary at the time the annual statements are mailed but not less than one month prior to the annual meeting with the request that they indicate their preference on the ballot to be returned in envelopes marked ballot. Members may vote for the candidates listed or write in names of their choice. The votes shall be tabulated by a special committee of members selected by the Secretary. The candidate respectively for President and First Vice-President who receives a majority shall be certified to the regular Nominating Committee, which shall announce the result at the ensuing annual meeting.

B. The following change in the composition and charter of the Committee on Popular Entomological Education were approved. The continuance of a Committee on Popular Entomological Education is recommended to carry on the duties originally assigned when the Committee was created.

In addition to these duties, it is suggested that the Committee develop a plan to supply to editors of popular, trade, commodity association magazines, the commercial press and such other avenues as might carry entomological subject matter to the general public the basic scientific data from which popular articles might be developed.

The present Committee is commended for the excellent work which they have accomplished. In order to facilitate the enlarged scope of activities above suggested, it is recommended that the present Committee be discontinued and a new method for selection of membership be adopted. The Chairman, as representative of the Association shall be nominated and elected by the Association and shall serve for a period of three years. Four additional members, each to represent a separate Branch, shall be elected by the Branches to serve for a period of one year or until their successors are chosen.

It is further provided that the incoming President of the Association shall appoint one member to represent each of the four Branches who will serve until members are elected at the next annual meeting of each of the Branches.

C. "The Executive Committee in conference with past Presidents Bishopp, Davis, Houser, Parker, Sanders and Sherman decided to obtain from the members present at the final business session an expression with regard to the donation of $2,000 to the building fund of the American Association for the Advancement of Science. This sum is to be taken from the Permanent Fund upon approval by a ⅔ majority of all members voting in a letter ballot." This was unanimously endorsed by the past Presidents, approved by the Executive Committee and passed by the members without dissent.

D. The Executive Committee requests the Publication Committee to make recommendations in regard to the expenditure of the Special Journal Saving Fund. Approved.

E. Since the size of the Index to the Literature of American Economic Entomology on the five year basis is becoming unwieldy and the task of transcribing the records from the cards under present conditions is extremely difficult, the Executive Committee recommends a change to a yearly basis subsequent to the period covered by Volume VII and that hereafter the yearly volumes be furnished to the membership unbound in order that each member may assemble and bind subsequent issues in such manner as each may determine as most usable.

F. The Executive Committee recommended and the meeting approved the addition of three ex-officio members to the Grasshopper Research Committee as recommended in the report of that Committee which appears elsewhere.

G. The Executive Committee recommended that the Post War Planning Committee be discontinued and the thanks of the Association be extended to the membership. Approved resolutions proposed by the Committee will be given given consideration by the Executive Committee.

H. The Secretary was authorized to attend Branch meetings in the mutual interest of the Branches and the Association whenever desirable and practicable, at the expense of the Association.

I. Determination of the place of meeting for next year was deferred until after the meeting of the AAAS in St. Louis on March 27 in order that the schedule of that Association may be considered in the preparation of our plans. The final decision as to time and place was left to the Executive Committee.

J. The Association approved the petition of a group of members for the formation of a SECTION ON INSECTICIDES and the officers who had been nominated. The statement of objectives and procedure is published elsewhere in these proceedings.

K. The report of the Resolutions Committee, which appears elsewhere in these proceedings, was adopted.

L. The report of the Nominating Committee was accepted and newly elected President Clay Lyle, was escorted to the chair by Past-presidents F. C. Bishopp and Franklin Sherman.

NEW BUSINESS

Dr. Peairs moved that the scope of the duties of the Committee on Common Names of Insects be extended to include the following: A. The Committee may propose common names for any insects for which a need may become apparent and submit these for approval along with lists of names proposed by others, especially when it seems that this will prevent confusion in the literature. B. The committee may modify, editorially or otherwise, existing common names in any case where uniformity will be

promoted or confusion avoided by such action. C. The committee shall prepare a list of common names for groups of insects, especially families, and submit such names for the approval of the membership as is done for names of species. The list shall include such long-standing common names as are deemed satisfactory and others as the committee may decide. An initial list of group names will be prepared and additions to the list made from time to time in the future as they seem to be needed and available in satisfactory form. Carried.

A motion was made and passed that the meeting be adjourned.

PROPOSED SECTION ON INSECTICIDES

In accordance with Article 2, Section 2 of the Constitution of the American Association of Economic Entomologists, the undersigned hereby petition for the establishment of a SECTION ON INSECTICIDES.

The aims and purposes of this section are as follows:

a. To promote and develop a free exchange of information, ideas and opinions among those engaged in the study of insecticides.

b. To provide a forum for the informal discussion of technical problems relating to the development of chemicals and their application for the control of insects and related pests.

PROCEDURE: Meetings shall be held, in connection with the annual meetings of the Association, at such times as may be convenient and as are not in conflict with the scheduled meetings of the Association as a whole.

Presented for approval at the Annual Meetings of the Association held at Dallas, Texas, December 3–6, 1946, bearing the signatures of the following members who recommend the approval and establishment of the Section.

HARRY F. DIETZ	GEO. S. LANGFORD
ROY HANSBERRY	S. W. Bilsing
GEORGE C. DECKER	C. P. CLAUSEN
HAROLD WATERS	J. L. HORSFALL
G. E. CARMAN	C. O. EDDY
C. S. HARRIS	E. N. CORY
L. M. PEAIRS	F. C. BISHOPP
HOWARD A. JONES	D. L. VAN DINE
ROBERT L. METCALF	OLIVER I. SNAPP
E. F. KNIPLING	GEO. M. LIST
J. J. DAVIS	A. F. KIRKPATRICK
J. G. SANDERS	W. A. PRICE
FRANCIS E. CARROLL	S. C. DORMAN
JOHN T. CREIGHTON	K. M. KING

Subject to the approval of the Nominating Committee and the Association, officers of the Section were proposed as follows: President, George C. Decker, Secretary, C. S. Harris.

REPORT OF THE RESOLUTIONS COMMITTEE

The Committee on Resolutions submits the following report:

1. WHEREAS: The members of the American Association of Economic Entomologists, in attendance at the fifty-seventh annual meeting of this Association held in Dallas, Texas on December 3 to 6, 1945, have enjoyed a most pleasant and profitable period of assemblage.

   Therefor, be it resolved: that we hereby express our cordial appreciation to the following individuals and agencies who made this occasion possible.

   a. Dr. E. W. Laake and members of the local committee on arrangements for working untiringly in the interests of all in attendance.
   b. The members of the Program Committee for an excellent program which was formulated on such short notice.
   c. The members of the Texas Entomological Society and the Cotton States Branch of the American Association of Economic Entomologists for serving as hosts and holding their annual meetings with the Association.
   d. The entire administrative and operational personnel of The Hotel Adolphus for making every effort to fulfill our requirements.
   e. The authorities of the Mexican Department of Agriculture for sending such an able and personable representive as Ing. Alfonso Delgado de Garay.
   f. Dr. S. W. Geiser of the Southern Methodist University for his excellent address which was presented as a feature of the annual banquet.
   g. Our President and Secretary for so ably fulfilling their duties during the meeting, and
   h. The members of all three organizations who made presentations during the several sessions.

2. WHEREAS: Many members of our Association in the armed forces, U. S. Public Health Service and other agencies, have made great contributions in the winning of the war that has been terminated during the present year.

   THEREFOR, BE IT RESOLVED: That we hereby extend our heartfelt thanks and admiration and wish them Godspeed in future years wherever they may be called upon to serve.

3. WHEREAS: The names of leading economic entomologists were not starred in the first seven editions of *American Men of Science* because the editor did not invite such nominations; and that since it would seem desirable to accord such recognition to men of accomplishment in economic entomology and other applied sciences.

   THEREFOR, BE IT RESOLVED: That the Executive Committee of the American Association of Economic Entomologists be instructed (1) to suggest to the publisher of the next edition of *American Men of Science* that the starring system be extended into the Applied Sciences and (2) to offer to the publisher the facilities of the Association to assist in working out an equitable procedure for the determination of the names of economic entomologists to be starred.

4. WHEREAS: The danger of introduction of new insects which might cause untold damage to agricultural crops has been great during war years, and

   WHEREAS: The sooner a new pest may be detected following introduction, the greater the possibility of successful eradication efforts, and thereby prevent continuous loss in agricultural production, and

   WHEREAS: Such infestations are more likely to be discovered early by carefully planned field surveys with trained workers.

   THEREFOR, BE IT RESOLVED: That the American Association of Economic Entomologists indi-

cate to its members the possible desirability of bringing to the attention of all agricultural interests and agencies the apparent need for National and local field surveys for such new introductions, and the value derived therefrom.

5. WHEREAS: It is recognized that the pink bollworm is the most destructive insect known to infest cotton, and whereas since an insignificant infestation of this insect found in the lower Rio Grande Valley of Texas and Mexico in 1936 has spread, in spite of all suppressive efforts, along the Gulf Coast and to points in Louisiana, involving in Texas about 725,000 acres and 5,000 more in Louisiana, and
WHEREAS: The pink bollworm infestation in West Texas is steadily moving eastward so that it now lacks only 100 miles of reaching the rich blackland cotton belt of Central Texas, and
WHEREAS: It is evident that the suppressive measures, even though successful in individual localities, have not been adequate as shown by the continuous spread, involving three-quarters of a million acres in South Texas and over a million acres in West Texas.
THEREFOR, BE IT RESOLVED: That the American Association of Economic Entomologists recommends to the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture and to the appropriate agencies of the states concerned that more stringent measures be applied, including requests for any additional legislation deemed advisable.
BE IT FURTHER RESOLVED: That our Secretary be instructed to send copies of this resolution to the Secretary of Agriculture, the Chief of the Bureau of Entomology and Plant Quarantine, the Chairmen of the Subcommittees of Congress on Agricultural Appropriations and to the State Commissioners of Agriculture of Louisiana, Texas and New Mexico.
6. WHEREAS: Dr. L. O. Howard and Dr. Herbert Osborn occupy a unique spot in the hearts of applied entomologists,
THEREFOR, BE IT RESOLVED: That our Secretary be instructed to forward them our sincerest greetings and best wishes.
7. WHEREAS: God in his infinite wisdom has seen fit to call from our ranks such worthy members as: Thomas M. Cannon, Thomas W. Johnson, John D. Maple, Max Rukin, H. G. I. Sameth and Ralph H. Smith. Members who died during the year 1944 include the following: Eugene W. Mendenhall, E. W. Berger, Harrison Garman, Louis M. Scott, P. H. Rolfs, William R. West, M. C. Tanquary, J. R. Horton, E. D. Sanderson, D. B. Mackie, V. I. Safro, Charles B. Beckwith.
THEREFOR, BE IT RESOLVED: That we pause briefly in our deliberations to pay our respects to these departed members, and instruct our Secretary to express officially our genuine sympathy to the nearest relatives.

K. M. KING — GUY F. MACLEOD
EPHRIAM HIXSON — GEORGE S. LANGFORD
JOHN T. CREIGHTON, *Chairman*

REPORT OF THE NOMINATING COMMITTEE

To the President and Members of the American Association of Economic Entomologists:

The Nominating Committee makes the following recommendations for officers, members of committees, trustees, representatives and councilors for the year 1946:

President: Clay Lyle
First Vice-President: H. G. Crawford
Vice-Presidents (Chairman of Branches and Sections)

H. F. Dietz	Eastern Branch
R. C. Gaines	Cotton States Branch
H. J. Ryan	Pacific Slope Branch
J. J. Davis	North Central States Branch
Roger B. Friend	Section of Plant Pest Control & Quarantine
F. L. Thomas	Section of Apiculture
R. W. Leiby	Section of Extension
R. C. Smith	Section of Teaching
George C. Decker	Section on Insecticides

Branch and Section Secretaries:

B. F. Driggers	Eastern Branch
H. T. Creighton	Cotton States Branch
Roy E. Campbell	Pacific Slope Branch
M. D. Farrar	North Central States Branch
Roy G. Richmond	Section of Plant Pest Control & Quarantine
W. A. Price	Section of Apiculture
E. Hixson	Section of Extension
W. P. Hayes	Section of Teaching
C. S. Harris	Section on Insecticides

Executive Committee:
Clay Lyle, Chairman (ex officio)
D. L. Van Dine (1947)
G. M. Bentley (1948)
Committee on Membership:
H. L. Sweetman (1947) Chairman
C. H. Batchelder (1946)
A. D. Borden (1946)
A. B. Baird (1947)
L. L. English (1948)
J. C. Gaines (1948)
Committee on Common Names of Insects:
C. F. W. Muesebeck (1947) Chairman
H. M. Harris (1948)
F. W. Poos (1948)
Publications Committee:
J. J. Davis (1948) Chairman
S. E. Flanders (1948)
Program Committee:
C. E. Palm (1948)
Committee on Codling Moth:
B. A. Porter (1947) Chairman
Dwight Isely (1948)
W. J. O'Neill (1948)
Committee on Insecticide Terminology:
C. H. Richardson (1948) Chairman
H. H. Shepard (1950)
Committee on Popular Entomological Education:
M. P. Jones (1947) Chairman
Committee on Cooperation with Pest Control Operators:
E. G. Linsley (1946) Chairman
F. W. Fletcher (1948)
Committee on Relation of Entomology to Conservation:
S. A. Graham (1946) Chairman
R. D. Glasgow (1948)
H. B. Mills (1948)
Committee on Grasshopper Research:
J. H. Pepper (1947) Chairman
Claude Wakeland, ex officio
J. R. Parker, ex officio
R. H. Handford, ex officio
D. A. Wilbur (1948)
H. L. Seamans (1948)
G. C. Decker (1947),
C. E. Mickel (1946)

Board of Trustees of the Permanent Fund:
Clay Lyle, ex officio
H. B. Weiss (1948)
Trustees for Crop Protection Institute:
A. M. Boyce (1946) Chairman
H. D. Tate (1948)
Representative on Council of Union of Biological Societies:
R. B. Friend (1947)
Councilors for the American Association for the Advancement of Science:
R. C. Smith (1948) Alternate
Representative to the National Research Council:
P. N. Annand (June 30, 1949)

Adjustments have been necessary in the composition of the Membership Committee to bring it in line with the wishes of the Association as expressed by vote at previous meetings. The Committee originally consisted of 3 members, appointed by the President for one year. In 1913 the constitution was amended, making it a standing committee, with one new member elected each year and thus establishing a 3-year term for the members. In 1939 the Committee was enlarged to 5 and in 1940 to 6, but no provision was made for a fixed term of office. With 6 members it was obviously the intent of the Association in approving the increased number, to continue the 3-year term. Accordingly, 5 members of the present committee who have served for 3–5 years are being replaced by the same number of new members, with their terms adjusted so that, hereafter, 2 new members will be elected each year.

It is recommended that the necessary steps be taken to amend the Constitution to provide for the 3-year term of members of the Committee on Membership.

H. F. DIETZ C. H. RICHARDSON
C. P. CLAUSEN, *Chairman*

REPORT OF THE SECTION OF EXTENSION

The Extension Entomologists' Program:

1. Extension Entomology in the South and West—M. P. Jones, leader, presented Mr. E. C. Martin, Specialist Supervisor, Texas Extension Service.

Mr. E. C. Martin discussed the relation of the specialist and district agent. In Extension work, the district agent is the key man. He should go with the specialist and learn his problems. He should inform himself so that he can do follow-up work with the county agent.

The specialist is the salesman. He should sell the district agent on his program first. Always use simple language. Discuss insecticides by brand names and on their merits good or bad.

Educate the administration. They know too little about the entomologists', field and its importance.

Train the 4-H Club.

Believe in your program and sell it on its merits.

2. Livestock Insect Control in an Extension Program—J. N. Roney, discussion leader.
3. DDT in Extension Work—Clay Lyle, leader.
4. New Problems, Methods and Programs—W. C. Nettles, leader.

R. W. Leiby was elected chairman for 1946 and Ephriam Hixson was elected secretary.

SECTION OF APICULTURE

The Section of Apiculture held its meeting in the afternoon of December 4, 1945 in the Danish Room of the Hotel Adolphus, Dallas, Texas. The Chairman, Robert S. Filmer, presided over a program consisting of eight numbers, two of which were read by title only. The principal discussions centered around such live topics as nectar secretion from white dutch clover and red clover, pollen substitutes, pollination of alfalfa flowers by insects, bee poisoning and the control of American foulbrood through the use of drugs.

Based upon the report of the nominating committee and subsequent election, the officers for the coming year will be: F. L. Thomas, Chairman; W. A. Price, Secretary.

W. A. PRICE, *Secretary*

REPORT OF THE COMMITTEE ON COMMON NAMES OF INSECTS

Early in 1945 ballots containing 51 new common names and 7 proposals for changes in previously approved names were distributed to the membership of the Association. Twenty-six of the new common names were approved but none of the proposed changes was accepted. A list of the approved names was published (JOUR. ECON. ENT. 38: 515. 1945).

Since there is continued demand for reprints of the list of common names published in 1942 and the supply is exhausted, the Committee recommends that a new complete list be published in 1946. This would include the names approved in 1945 and any that may be approved from a list which it is proposed to submit for vote early in 1946. Forty-two names are now on hand for the Committee's consideration. To obviate the necessity for annual voting and publication of supplementary lists of approved common names, the next complete list ought to include as many as possible of the insects not now represented for which authorized common names should be available. The Committee urges, therefore, that members of the Association review the situation in the fields of their individual interests immediately and submit any proposals to the chairman. Each proposal should be supported by a brief statement explaining why the suggested name is considered appropriate.

U. C. LOFTIN* E. H. STRICKLAND
J. S. HOUSER DON C. MOTE
CLAUDE WAKELAND C. F. W. MUESEBECK, *Chairman*

* Necea Sed.

REPORT OF THE BOARD OF TRUSTEES OF THE PERMANENT FUND

The Auditor's report shows the status of the Permanent Fund and requires only brief comment. Five thousand dollars in savings bonds were called as of November 1, 1945. These were forwarded to the Federal Reserve Bank by the Prince Georges Bank and Trust Company as our agent and subsequent to the audit, a check was received which was used by directions of the Trustees in the purchase of a like amount of Series G Bonds. These will appear in the list of securities for next year. One life membership fee was added to the fund in 1945.

F. C. BISHOPP C. J. DRAKE
D. L. VAN DINE H. S. SMITH
E. N. CORY, *Chairman*

REPORT OF THE MEMBERSHIP COMMITTEE

The membership committee submits the following report for the year 1945.

Six members have died during the year, as follows:—

Thomas M. Cannon	Max Rukin
Thomas W. Johnson	H. G. I. Sameth
John D. Maple	Ralph H. Smith

Fifteen members have resigned and 21 have been dropped from the membership rolls.

The name of Nellie M. Payne, Stamford, Conn., has been added to the list of life members.

The applications of the following men have been received and considered and the applicants are recommended for membership.

G. M. BENTLEY LEROY CHILDS
S. W. BILSING, *Chairman*

MEMBERS ELECTED, 1945

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Gregg, Paul, College Station, Tex.
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REPORT OF THE COMMITTEE ON INSECTICIDE NOMENCLATURE

A GUIDE TO INSECTICIDE NOMENCLATURE

Chemicals. The first reference to a chemical in the text of a JOURNAL article shall use the terminology as given in the indexes of *Chemical Abstracts* issued subsequent to 1937. Where a new chemical not listed in *Chemical Abstracts* is named, rules of nomenclature followed by *Chemical Abstracts* shall be used. At the author's discretion, abbreviations, simplified, common, or pharmaceutical names may be used, if such names are associated with the correct name where first used.

Examples of proper usage:

1. "Toxicity of DDT and pyrethrum to *Chaoborus punctipennis*." Arthur W. Lindquist and R. C. Bushland. The new insecticide, DDT (2,2-bis-parachlorophenyl)-1,1,1-trichloroethane) has, been tested. . . .
2. Only one application was made, and with the exception of corrrosive sublimate (mercuric chloride) and dichloroethyl ether, all treatments were used as dusts. Calomel (mercurous chloride) was prepared. . . .

Chemical Formulas. The use of chemical formulas shall be at the discretion of the author and the editor of the JOURNAL. As a guide the author shall use formulas only where the printing is simplified (HgCl for mercurous chloride) or occasionally where such use will help the reader visualize the structure of a complex organic chemical. Structural formulas of complex organic compounds should be used only when necessary to convey information not readily adapted to standard type. Abbreviations of certain formulas used in *Chemical Abstracts* (such as EtOH for ethyl alcohol) shall not be used in the JOURNAL.

Botanicals. The first reference to an insecticide of plant origin (other than rotenone, nicotine. or pyrethrins) shall be in conjunction with the scientific name and author of the plant species. Composition of insecticides based on plant products shall be specified wherever possible (dust containing 10 per cent ground root of *Derris malaccensis* (Benth.) Prain; 0.1 g. pyrethrins per 100 g. of pyrethrum mare).

Minerals and Mixtures. Reference must be made to both trade name and mineralogical name in case of minerals or trade names and their approximate chemical composition or physical properties in case of such mixtures as kerosene, London Purple or DD soil fumigant.

Abbreviations. It is not the present intention of the Committee to suggest abbreviations for other than quantitative terms. For such terms Chemical Abstracts shall serve as a guide.

Trade-Marked Names. These shall be used (1) only for the purpose of simplification following a full statement of forumulation or, (2) where the composition of the mixture is known not to have been recently changed and the manufacturer has stated in good faith that the composition will not be changed in the future. Wherever practicable, trade marked names should be relegated to a footnote and a simple but adequate chemical name be used in the text and tables.

Definitions. Definitions acceptable to all Entomologists can only be established after considerable discussion. Until subsequent committees are able to establish such definitions, those given in Phytopathology *33* (7): 624–625, July, 1943 shall be, used. Special care shall be taken to adhere strictly to accepted scientific usage of such non-scientific terms as spreader, sticker, average particle size, and residue.

General. It is neither the desire nor the intent of the Committee to provide an inflexible lexicon of insecticidal terminology. The foregoing guide to nomenclature is offered as an initial effort to unify usage of terms often employed in discussing insecticides. If an author is guided by the fact that his contribution must have meaning and provide knowledge to Entomologists in foreign countries during future years the use of trade names, names of mixtures and minerals, and of technical terms will be adequate and descriptive.

M. D. FARRAR R. C. ROARK
C. H. RICHARDSON J. R. EYER
ROY HANSBERRY, *Chairman*

REPORT OF THE COMMITTEE ON POPULAR ENTOMOLOGICAL EDUCATION

The report of the first Committee on Popular Entomological Education states in part that:

"Your committee inaugurated its work by circularizing the entomologists in the Association requesting that they put forth a special effort to release through the press, radio, exhibits and other avenues as much entomological information as possible and that they attempt to ascertain through press clippings the extent to which the work gained recognition."

Subsequent reports have consisted pretty largely of statistical reports on the various kinds of publicity given entomological subjects. Your committee feels that there is not much point in continuing such reports. However, an examination of all the different press and radio releases coming to the attention of the various offices in Washington indicates that the entomologists in some states are doing a good job in keeping their subject matter before the public, while workers in other states issued relatively few articles. Most of you are familiar with the type of informational material prepared in the U. S. Department of Agriculture, and the efforts of the Bureau of Entomology and Plant Quarantine to distribute entomological releases and publications to the people in key positions in the states. Many of the press and radio releases so distributed are localized by state workers and are used in many states along with material they prepare. Now that the war is over, the restrictions on the press are easing up and competition with war news is past. Entomologists should take advantage of this and avail themselves of every opportunity to keep correct entomological information before the public. By so doing they may help offset erroneous information from unreliable sources.

The broad functions of the committee have been stated but upon attempting to formulate a program we have found it exceedingly difficult to determine concrete lines of action that are open to the committee. Popular entomological education in general falls within the fields of Teaching and Extension. For example, the following suggestions of possible activities for this committee have been submitted. One is that it make a study of informational material to find out what makes some items popular while others apparently worthy of recognition are brushed aside. Is popularity entirely subject matter content or does the method of presentation help to sell the subject of entomology?

It has also been suggested that with all the publicity relative to DDT and its uses, the information which has been published on this subject might well be considered in some detail, since some of the information has been good, but it might have been better if a great deal of it had never been published. Were this committee to report on such a study, in what way could it help the dissemination of information which is premature or erroneous.

The apparent inadvertent listing of the name of this body as the Committee of Entomological Education, instead of the Committee on Popular Entomological Education in the official roster following the last meeting, prompted another suggestion. Omission of the word "Popular" from the title places the emphasis more specifically on the academic aspects, in which case the committee might be expected to make a study of entomological education at the various colleges. Recommendations following a study of the curricula for undergraduates might lead to improving the entomological training afforded students. Would a study of this kind fall within the province of the present committee or is that the function of the Section of Teaching?

Undoubtedly there are comments on these suggestions and other ideas as to work which a committee of this kind might perform, and your present committee will welcome a liberal discussion of his whole matter. If it is the wish of the Association that the present committee be continued, we would appreciate concrete suggestions for activities that do not overlap the fields of teaching and extension. If the membership feels that the work of the present committee is completed or is now being covered by agencies within the association, it is our recommendation that this committee be abolished.

JOHN T. CREIGHTON J. O. PEPPER
J. A. HYSLOP M. P. JONES, *Chairman*

REPORT OF COMMITTEE ON GRASSHOPPER RESEARCH

The objectives of this Committee are to stimulate and to unify grasshopper research in the United States and Canada. In pursuit of these objectives the Committee conducted three major activities in 1945: (1) Assembled and issued the third annual (confidential) report on the results of grasshopper research in three parts comprising respectively the work conducted in 1944 by state agencies, the United States Bureau of Entomology and Plant Quarantine, and the Canadian Division of Entomology. (2) Sponsored a conference, held at Lincoln, Nebraska, September 11 to 14, 1945, of 35 research men and others closely concerned with the grasshopper problem, representing 11 states and the Canadian and United States Departments of Agriculture. (3) Was enabled at that time to hold its own first general meeting, in which its two past chairmen H. C. Severin and J. R. Parker also participated at its invitation.

A detailed report of the conference discussions will be issued in mimeographed form. The present statement summarizes the work of the Conference, particularly as to its conclusions and recommendations.

The conference was designed to be a major step towards: replanning and reorganizing grasshopper research on a more efficient, more comprehensive, more fundamental basis; improving coordination and unification over the entire natural region; stimulating and utilizing all available contributing bodies, state as well as federal; and showing the need for a substantial increase of moral and financial support for this research, without which progress towards the solution of this pressing problem will be gravely handicapped. Periodic conferences of this sort are recognized to be essential to the healthy development of research, especially when the problem involves such a wide and diverse area and relationships as with grasshoppers. The need for a general conference on grasshopper research had been increasingly felt, since no large group meetings had been possible during the war years, and in fact no conference representative of the whole area had ever been held.

The exchange, in advance of meeting, of 14 outlines representing various group or individual views as to grasshopper research objectives, permitted the conference to concentrate its time on discussion of and decision upon an over-all, unified program, the place and emphasis for each part, and specific recommendations as to ways and means of achieving this program.

To assist in crystallizing and giving expression to the various ideas as to the relative urgency of various types of research activities, informal voting was carried out. While there was rather wide variation between individuals, the average result seemed broadly significant of group opinion. The first question was: "From your appraisal of their probable contribution towards advancing the solution of the grasshopper problem, what per cent of resources (men, funds, equipment) would you allocate at this time to each of the following major divisions of grasshopper research: (A) Physiology, fundamental toxicology, morphology, taxonomy; (B) Long-range ecological investigations, such as population studies; (C) Immediate control and prevention." The average response was, respectively, 28 per cent, 35 per cent, and 37 per cent. In the second testing of opinion, ratings in terms of relative urgency were asked for 16 items roughly representative of the three major divisions.

With the general guidance thus afforded, the Conference divided into three sub-groups having as leaders A. Glenn Richards, R. H. Handford and J. R. Parker. Each was asked to note specific points where information seemed most needed as bearing on control, the agencies now working on the problem, and suggestions as to where additional work might be undertaken. The three reports, as approved by the Conference, are given in part below with special emphasis on these critical points.

A. PHYSIOLOGY, MORPHOLOGY, TAXONOMY

Basic work in taxonomy is desirable to grasshopper control workers in order that they may positively identify the species they encounter. Basic work in morphology is desirable in so far as it is a necessary prerequisite to taxonomic, physiological and ecological problems. Basic work in physiology is desirable as a basis for a rational interpretation of grasshopper activities and grasshopper control procedures. It is conceivable that satisfactory methods for grasshopper control might be developed by empirical studies without any of these basic studies but it is the feeling of the Conference that basic studies can assist in directing the course of control research by interpreting some of the activities observed in the field and that possibly basic work may suggest modifications or even new lines of attack for control.

We feel impelled to point out that unless the numbers of research physiologists and physiological laboratories are increased this type of work cannot proceed at an efficient and desirable pace, and so cannot, with sufficient promptness, answer the questions raised by control men.

While many grasshopper projects are long-term jobs, physiological work is relatively easy to alter from time to time. Physiologists can afford to and must experiment with variations in technique during a project. Complete planning in advance is not desirable. Ecologists and field workers are often more restricted in varying their programs.

Physiological work must be carried on by persons trained in physiology. Some of the problems should be carried on in collaboration with physicists, chemists or other specialists. By and large we must depend on institutions because of questions of equipment and freedom. Costs cannot be predicted but equipment and upkeep in physiology are relatively expensive. Finally we do not feel that physiological problems can be assigned at random. Workers must be interested in the problems as well as trained in the techniques.

No especial priority is implied in the sequence of the following major items:

1. Study of sensory physiology of grasshopper species to understand behavior in relation to such factors as light, weather (in all its constituent parts), attractants. By identification of types and mapping of sense organs, and systematic testing of the response of grasshoppers to various external stimuli, singly and in combination, and in relation to the physiological state of the grasshopper.

2. Study of nutrition; relation of basic data on nutrition to food preferences, reproduction, longevity, phase development and general activities. Both chemical and observational approach, and analysis of effects of nutrition on reproduction, longevity and general activities. In relation to control, these studies can only be expected to yield basic data which must then be studied and re-interpreted in relation to the activities of grasshoppers in their natural environment.

3. Studies on reproduction exclusive of nutritional relationship to interpret increase of populations. By research on population genetics, developmental morphology, and diapause phenomena; and factors of natural environment in relation to the above.

4. Studies on the physiology of population changes, to determine whether phase differentiation is a reality for North American species, to determine the factors producing these changes, and to evaluate the significance of such changes. Very little fundamental research seems to be in progress but we feel strongly that this point warrants intensive study.

5. Studies on the physiology of insecticide action, to understand and thereby possibly improve insecticide formulations. Basic physiology must precede physiological toxicology. Actual toxicology and the physiological basis thereof (pharmacology) are distinct but related aspects of the same question, and can be studied separately. Even in projects devoted exclusively to grasshoppers it is commonly advantageous to employ comparative methods using various insects. Actual toxicology is studied by systematic testing of compounds. The physiological basis of insecticide action is determined by physiological studies which incorporate insecticides, using such promising technical procedures as penetration and membrane studies, enzyme studies, tracing the path of toxins, analysis of growth stimulators and inhibitors, and the effect of sublethal doses on reproduction and other activities. Numerous institutions and many commercial firms are working on actual toxicology; only a few on insecticide pharmacology. Pharmacology is a specialized phase of physiology and requires excellent laboratory facilities. Most of the properly equipped laboratories have some work in progress and the most feasible suggestion would seem to be to encourage expansion and elaboration of these programs.

6. Taxonomic studies on various stages, to provide means of identification of nymphs and eggs as prerequisite to accurate population estimates.

B. Populations and Ecology

A thorough knowledge of grasshopper populations and the environmental factors affecting them will bring about increased accuracy and decreased cost of forecasting grasshopper outbreaks, and increase the possibility of farmers and ranchers carrying on with only a minimum of loss during grasshopper outbreaks. Research on populations and nearly all of the environmental factors is being carried on here and there by state, federal and dominion agencies, although some important phases of the work are not being investigated at all. Ecological investigations already under way should be fully maintained. Listed below, approximately in order of their urgency, are projects which the conference felt should be given greatly increased attention immediately:

1. The development of methods of determining absolute numbers of eggs, nymphs, and adults for all species; with state and federal institutions carrying on definite phases of the work under a unified leadership. Investigations to improve the methods of estimating nymphal and adult populations. Further attention to the adequacy of egg surveys for various species, localities and situations.

2. The mapping of primary and secondary grasshopper areas from the data and records already available. Efforts to establish the existence of endemic centers of primary and secondary importance should be continued for all economic species.

3. Detailed, almost continuous, "on-the-ground," studies throughout the season, in selected grasshopper areas, of populations and development of all economic species and complexes, together with similarly detailed studies of all environmental factors (both natural and man-made) considered in relation to each other as well as to the grasshopper populations.

4. Weather data: especially as to their completeness and suitability for use in conjunction with the detailed studies just indicated.

5. Diseases, parasites, insect and other predators; their incidence and net effectiveness; the cataloguing of disease species, and the biology of insect parasites and predators. It is felt that special study of diseases is needed, but that progress in it will not be satisfactory until a special laboratory is established which will facilitate a concentrated, cooperative attack on the problem by pathologists as well as entomologists.

6. Soils, agricultural (including conservation) practices, and plant cover; in relation to grasshopper abundance and species distribution.

C. "Immediate" Control and Prevention

The following research problems are listed in the order of importance indicated by the vote of the Conference:

1. Empirical testing of more promising insecticides, baits, attractants, etc. It is recommended that major attention be given to the immediate testing of dusts and sprays and the improvement of equipment for their application. Some work should also be done immediately on developing better methods for evaluating baits. Information from physiological and behavior studies may supply leads which will make future bait research more productive.

2. Tillage. The limited information now available indicates the importance of tillage in grasshopper control programs. Greatly increased and widely representative experimentation, and the development of uniform methods of appraising the value of tillage operations, are urgently needed. Special studies of soil conservation practices in relation to grasshopper abundance and control should also be initiated as soon as possible. It is the opinion of the Conference that such research can be conducted most advantageously by State Experiment Station entomologists in close cooperation with agronomists, soil conservationists and other interested agencies.

3. The practicability of control during incipient stages of increase should be tested in an incipient outbreak area of the largest size in which it is practical to carry out complete control of grasshoppers on all infested land and to determine the results with respect to crop protection for the current year and population reduction for the succeeding year.

4. Control by cropping systems and the development of grasshopper resistant varieties of plants is recognized as a field of research offering great rewards. State agencies are best qualified to determine the cropping systems and varieties best adapted to their respective states.

5. Economic evaluation of control methods. Research should be conducted to derive a practical, dependable method for evaluating the results of control in terms of grasshopper populations and in crop damage. This method should be adaptable for use as a basis for training field men in determining accurately the effectiveness of the control measure employed as well as in recognizing and accurately appraising crop losses and savings. It is desirable that this work be developed in cooperation with agricultural economists, crop insurance appraisers and crop reporting agencies.

6. Experiments in the use of parasites, predators and disease as control measures are considered highly desirable but basic studies should precede experiments in control. The Conference recommends that when experiments in control are started, priority should be given to the artificial use of diseases.

7. Range management appears to offer a means of reducing the damage caused by range grasshoppers but experiments to measure its value cannot be planned intelligently until the habits and seasonal histories of the numerous range species are better known. In the meantime, every opportunity should be taken to observe range grasshoppers on areas where controlled grazing is practiced. Uniform methods of making observations and recording data should be established.

INCREASED FUNDS NEEDED

Summing up the convictions of the Conference, the following resolution was carried unanimously on motion of C. E. Mickel seconded by Claude Wakeland:

"The discussions of the grasshopper research workers at the Conference held at Lincoln, Nebraska, September 11 to 14, 1945 have brought out clearly that the primary difficulty in arriving at a satisfactory solution of the North American Grasshopper pest problem is the lack of research funds and personnel for attacking this exceedingly complex problem. We have spent hours in exploring the possibilities of procedures for getting research done by make-shift methods with the inadequate funds now available and are convinced that such procedures are entirely inadequate for the solution of the problem.

"Millions of dollars have been appropriated and spent during the past twenty years by state, provincial, federal and dominion agencies for materials and labor for the applied control of grasshoppers. During the same period the amount of money spent on research for a solution of the grasshopper problem has been woefully inadequate. We are convinced that each million dollars spent on grasshopper research now will save hundreds of millions to the people of the United States and Canada in future emergencies.

"We therefore earnestly recommend that the United States Congress, the Parliament of the Dominion of Canada, and the affected states and provinces join in providing adequate funds for the support of research of this most urgent problem."

COORDINATION OF GRASSHOPPER RESEARCH

The Conference recognized the pressing need for greater unification and integration of the research relating to grasshoppers, and for bridging the gap between planning and action. After mature consideration of these needs, it recommended that every effort be made to secure the services of a full-time secretary to this Committee, to facilitate cooperation between the various agencies—state, provincial, federal, dominion, and industrial—engaged or interested in grasshopper research. Their cooperation would, as before, be entirely voluntary. The secretary would not have power either to determine or to enforce policies. The recommending of general policies to the various agencies concerned remains in the hands of the research group as a whole after soliciting the view of other interested parties. Yet it was clearly the unanimous conviction of the Conference that the employment of an independent regional coordinator, if of the requisite ability and qualifications, could contribute more to the over-all advancement of grasshopper research than any other single step of comparable cost. It therefore charged your Committee to canvass ways and means of establishing, financing and directing the secretaryship, and of securing the services of an entomologist well qualified for the post.

As further contributing to unity and progress, the conference—on motion by C. M. Packard seconded by R. H. Handford—unanimously recommended that the Committee undertake to arrange every three years a general meeting on grasshopper research; and that there be informal meetings at lesser intervals of small groups of workers engaged in closely allied research.

COMMITTEE MAKEUP

The conference was of the opinion that the Committee on Grasshopper Research of the American Association of Economic Entomologists would have greater continuity and increased ability to perform the functions with which it is charged if, in addition to the usual six rotating members, three others were to be added as members *ex-officio*, namely, the grasshopper research leader and the chief of the division of grasshopper control for the United States Bureau of Entomology and Plant Quarantine, and the grasshopper research leader of the Canadian Division of Entomology. Your Committee therefore requests that the Association now consider this recommendation and make a change along these lines if it can see its way clear to do so.

Your Committee also solicits the approval and general support of the Association for the other actions and recommendations of the Conference.

F. A. FENTON — R. H. HANDFORD
CLAUDE WAKELAND — J. H. PEPPER
H. DOUGLAS TATE — K. M. KING, *Chairman*

REPORT OF THE COMMITTEE ON RELATION OF ENTOMOLOGY TO CONSERVATION

In each of its annual reports your committee has been repeating an appeal for an increased interest in conservation and the many entomological problems associated with conservation programs. You have been urged to contact those charged with the responsibility of planning and administering conservation programs and to discuss with them the entomological problems actually or potentially associated with their programs. Also, you have been urged to submit suggestions on how the committee might increase its usefulness.

It appears that we are making slow but constant progress. Entomologists in increased numbers report: Invitations to discuss entomological problems at Conservation meetings, appointments to positions on planning boards, engagements as speakers or lecturers at conservation schools or short courses and requests for interdepartmental conferences on problems of mutual interest. It is gratifying to note that in some states entomologists have taken the initiative in calling conferences of all agencies interested in such important entomological problems as mosquito, grasshopper and European corn borer control.

A recognition of the importance of unity of thought and singleness of purpose on the part of all agencies interested in conservation is growing within and without our Association. Early in 1945 a group of eminent biologists representing several societies met in New York for the purpose of discussing the possibility of forming a general conservation council.

It was proposed that this council should be composed of representatives of some 15 existing non-governmental organizations interested in conservation. The American Association of Economic Entomologists was invited to become a participant and to appoint a representative to the council. At its August meeting the Executive Committee of this Association accepted the invitation and designated the Chairman of this committee as your delegate. To date, the council has not met, but it is to be hoped that it will become active and serve a very useful purpose in guiding the development of long range conservation programs and in initiating action to deal with situations requiring immediate attention.

While entomologists serving in the armed forces were attracting attention and bringing credit to our profession by working miracles in insect control without excessive permanent damage to the natural fauna and flora of the areas in which they operated, the entomologists at home were proving to the world that they were conservationists at heart and that the special interests and problems of their fellow scientists were paramount considerations. The entomologists had in their hands a new and extremely promising insecticide. It became available in quantity and stimulated by voluminous and highly favorable publicity, the public was clamoring for its use. As a result of preliminary research by men in the Bureau of Entomology and Plant Quarantine and in practically every entomological research laboratory in the country, we had a fair knowledge of how DDT might be used and its potential value when applied to obtain the control of a great many serious insect pests. It was not recommended for general use, however, largely because entomologists were uncertain what effect its widespread use might have upon plants, soils, beneficial insects, and wildlife.

The U. S. Army and the U. S. Public Health Service, the largest users of DDT in 1945, acknowledged their interest in conservation in a joint statement of policy in which they assured the apprehensive that the use of DDT would be limited to projects conducted with due regard to the possible effects of DDT on beneficial insects and all forms of plant and animal life in accordance with safeguards established by the Surgeons General of the Army and the Public Health Service (see Editorial page, April number of the JOURNAL).

During the past year the Bureau of Entomology and Plant Quarantine and several entomologists of state agricultural experiment stations, working in close cooperation with the Fish and Wildlife Service, state conservation departments and representatives of various interested societies, have made very considerable progress in their attempt to determine the effects of DDT on wildlife. Your committee has been privileged to review manuscripts in press, reports of unpublished data and valuable opinions contained in personal correspondence which has been generously supplied by the Bureau of Entomology and Plant Quarantine, the U. S. Fish and Wildlife Service and a number of entomologists and conservationists associated with state and private institutions. Certain facts and conclusions gleaned from these sources are presented for your consideration.

The advent of DDT and its dramatization by speculative writers has produced two divergent veins of thought. The overly optimistic dream of a one-shot spray that will end all insect problems, and the overly pessimistic envision a world devoid of all forms of wildlife, of insect plagues by pests released from obscurity by the destruction of their parasites and predators, or of wholesale crop failures induced by the annihilation of insects active in the pollination of plants. Both are equally absurd, but they forcefully direct attention to a need for thorough and well coordinated research.

Unfortunately, most of the popular or speculative writing on the effect of DDT on conservation and practically all of the moaning and shouting about disrupting the balance of nature and destroying birds and other forms of wild life has been by those who have had little or no experience with DDT, and who have little or no first hand knowledge of insect control, wildlife management or conservation methods.

To date there seem to be no authoritative records of injury to mammals, ranging from mice, shrews and rats up to rabbits, foxes and deer, resulting from any reasonable DDT treatments applied to forest, marsh or other areas.

Fantastic reports of wholesale destruction of birds in areas where DDT has been used are based upon false rumors and have no foundation in fact. Trained biologists and competent ornithologists who have observed and studied a number of areas before and after applications of 1 to 2 pounds of DDT per acre have found very few dead, sick or otherwise affected birds. In some instances birds, particularly swallows and other insectivorous species, reportedly migrated out of treated areas soon after treatment, but nests were not abandoned and apparently the treatments resulted in little or no permanent disturbance or damage. The use of 5 pounds of DDT per acre has resulted in considerable bird mortality and one such treatment (through death and migration) practically eliminated a large bird population from the treated area.

The results obtained on the effect of DDT on fish and other aquatic life are somewhat erratic, due perhaps to variables such as food, feeding habits, temperature, ratio of volume to surface area and formulation. It appears that surface feeders and small species are more susceptible to DDT poisoning than are bottom feeders and larger species. In general, fish are not seriously affected by applications of 0.1 to 0.25 pound of DDT per acre but applications approaching 0.5 pound per acre or higher begin to affect some species. Applications of 1 pound per acre or more, at least under some conditions, may have destructive effects. Therefore, until the effect of DDT on fish and other aquatic life is better understood, every effort should be made to avoid overtreatment of streams and ponds. Aquatic insects, crustaceans, crabs, crayfish, salamanders, snakes and turtles are affected variably, but in some cases one pound of DDT per care reportedly kills moderate to large numbers of specimens.

Several laboratories have demonstrated that colonies of bees can remain vigorous and thrifty in orchards and other environments where DDT is used. The apiculturists' original fear has turned to a hope that DDT will prove to be less destructive to bees than lead arsenate and other insecticides now in common use.

It appears that parasitic and predatory insects like phytophagous species are variably affected by DDT. Some species are easily killed by very minute quantities and some survive the most severe treatments. In apple orchards where DDT has been used to control the codling moth, the destruction of predatory forms usually results in a serious increase in the mite population. It becomes increasingly apparent, however, that this subject, because of its

very complex nature, cannot be studied in the laboratory. Only through adequate large scale field tests under actual field conditions can we hope to determine the final effect of DDT upon all phases of a complex environment.

In planning experimental programs and in making commercial applications of DDT, it seems that some thought should be given to the timing of treatments. Applications before or after the blooming period of treated plants would at least in part protect bees and other valuable pollinating insects as well as other valuable dipterous and hymenopterous insects that frequently visit blossoms. Likewise timing applications to control newly hatched larvae instead of half or full grown caterpillars might reduce the hazard of birds, poultry or other animals being poisoned by eating dead insects.

While it is granted the use of DDT on large scale experimental areas may, we regret, result in the killing of a few birds or a few fish and temporarily upset the so-called balance of nature, every entomologist, naturalist, forester and conservationist knows that once the temporary disturbing influence is removed, the balance will be quickly restored. The Bureau of Entomology and Plant Quarantine (unpublished) has found that in a 40-acre timbered tract where most species of insects were greatly reduced by the application of 5 pounds of DDT per acre in 1944, the area had an apparently normal insect fauna one year later.

Since the information gathered thus far seems to indicate that reasonable applications of DDT that might be recommended by entomologists will have little direct effect upon birds or mammals and that any temporary disturbance in the insect population can be quickly readjusted, entomologists should feel free to encourage and plan large scale field experiments. In the treatment of aquatic habitats due consideration should be given to fish and other cold blooded animals. The use of DDT in limited areas inhabited by rare or unique species of birds or other animals should be avoided. To date large scale field tests have dealt largely with forest and marsh environments. The U. S. Fish and Wildlife Service has pointed out that 80 per cent of our game and a very high per cent of our non-game and insectivorous birds and mammals are largely dependent upon an agricultural environment. It is expedient therefore that all interested agencies should cooperate in setting up appropriate research projects that will adequately evaluate the use of DDT in this type of environment. In control operations it may at times be necessary to weigh the importance of objectives—eradiction or immediate control of serious insect infestations against the possible loss of a few birds or other wildlife.

Questions requiring answers include: (1) Is the danger of killing birds and other wildlife greater in agricultural environments than in forest areas? (2) Can the repeated applications sometimes required in the control of crop pests be made without endangering wildlife? (3) What minimum dosage can be established for effective insect control? (4) What maximum dosages can be tolerated by wildlife? (5) Can improved methods of formulation and application increase insecticidal efficiency and reduce the hazard to wildlife? (6) How does DDT kill birds, fish etc.—contact, poisoning food, other means? (7) Will the destruction of a considerable portion of the insect population in a stream or terrestrial environment cause depletion of the fish or bird population before the insects can repopulate the area? Your committee feels that the answers to these questions and many more which will develop as the work progresses should be obtained at the earliest possible date. In the meantime, entomologists and biologists alike should proceed cautiously and at the same time make every effort to determine the facts. We believe that only through the full understanding of these interrelated effects will the full use of this remarkable insecticide be available to the public.

F. E. WHITEHEAD F. C. CRAIGHEAD
S. A. GRAHAM J. A. BEAL
G. C. DECKER, *Chairman*

REPORT OF THE COMMITTEE ON CODLING MOTH FOR 1945

As in previous years, the Committee has requested the Bureau of Entomology and Plant Quarantine to assemble and cirulate a pool of current information on the results of codling moth investigations. Invitations to participate in this pool are being forwarded to various interested entomologists, and the pool will be issued during the winter. This will be the twelfth year that this service has been performed.

Consideration has been given to the possibility of holding a conference on the codling moth problem in view of the recent developments with DDT, and in view of the fact that none has been held for several years. Conditions, however, do not appear especially favorable for a resumption of these conferences and no plans are being made at the present time for one.

In several recent years the Committee has drawn up a number of suggestions for further work with the codling moth. These suggestions have been published in the JOURNAL OF ECONOMIC ENTOMOLOGY (Vol. 35, p. 134, 1942; Vol. 36, pp. 170–1, 1943; Vol. 37, pp. 174–5, 1944). The Committee has nothing to add to these statements at the present time, but would welcome suggestions or recommendations from the membership.

LEONARD HASEMAN B. F. DRIGGERS
W. S. HOUGH A. D. BORDEN
L. F. STEINER B. A. PORTER, *Chairman*

REPORT OF THE COUNCILORS FOR THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

In his report as delegate to the Cleveland meeting of the American Association for the Advancement of Science in September 1944, Dr. Roger C. Smith emphasized the desirability of closer contact between entomologists and the American Association for the Advancement of Science. Since then the importance of this suggestion is becoming more and more apparent. Reference was made in the Presidential address at the New York meeting of this Association to difficulties which entomologists are facing in our recent pronounced tendency to "go it alone." Attention has repeatedly been called to the unsatisfactory starring of names of scientists in *American Men of Science*. There have been several further evidences of the danger of this separatist point of view during the past year. They strongly indicate that a real effort should be made by entomologists to take an active place in scientific organizations of wide scope and to increase their acquaintanceship among those interested in related sciences.

The probable establishment of a National Scientific Research Foundation under one of the several bills for this purpose pending in Congress emphasizes the need for our more active participation in

general science activities. If entomological groups move further in the direction of separation from other scientific circles, we are very likely to be overlooked in connection with the organization of the scientific work under this proposed Foundation, and those engaged in basic entomological studies would suffer materially from such an oversight.

The present is an excellent time for us to take renewed interest in broad scientific work. The contributions of American entomologists to the control of malaria, typhus, and other diseases during the war has been so important and conspicuous that the public is becoming more conscious of the practicability of pest control than ever before. The potentialities of DDT are being discussed in popular and scientific journals and in radio addresses to a degree exceeded only by the attention given the atomic bomb.

Economic entomology is now thoroughly interwoven with the national and international aspects of both health and nutrition. The new procedures and treatments now under study by entomologists are deeply involved with chemistry, physics, and electronics, as well as with plant and animal physiology and ecology. It will be impossible for the Food and Agriculture organizations to act intelligently on the world distribution of food without consideration of pest-control problems in the countries concerned. Close contact with other scientific agencies is es ential, if full advantage is to be taken of the interrelationship between the rapidly advancing discoveries of entomology and those of other sciences.

Your councilors accordingly heartily renew the recommendation made last year that this association undertake more active support of and participation in the work of the American Association for the Advancement of Science, Section F, and the Union of Biological Societies.

With this in view the councilors have made a study of the organizational structures involved. The American Association of Economic Entomologists is only one of numerous "Associated Societies" affiliated with Section F of the American Association for the Advancement of Science. As an organization with over 100 of its members having the status of "fellows" in the AAAS, it is entitled to name two members on the council of the main Association. These two councilors are ex-officio members of the so-called "Section Committee," of Section F. This committee is now composed of some 38 members. The activities of the Section, however, are largely controlled by an executive committee, consisting of the chairman and secretary of the Section and four additional members who are elected by members of the Section Committee and who serve 4 years.

The Associated Societies in Section F include seven organizations devoted to various aspects of zoology, and seven having both botanical and zoological interests. In addition to the representatives of these 14 specialized societies, there are listed on the large Section Committee all those councilors for the Association who represent general organizations such as Sigma Xi and the numerous State Academies of Science in those cases in which the nominees happen personally to be interested in zoological fields. For example, the Texas Academy of Science was listed in 1944 as associated with Section F, due to S. W. Bilsing's election by the Academy to the council of the AAAS for that year. In case someone interested in another field should be elected to succeed Professor Bilsing when his term expires, the Texas Academy would appear under some other Section, rather than among the organizations associated with Section F.

During the fall of 1945, the Secretary of Section F sent to each member of the large Section Committee a ballot on which were listed some 6 to 8 nominees for the office of chairman and a similar number for member of the executive committee for 1946. These nominees had been proposed by the present executive committee and therefore represented largely the specialties already represented on that committee. Two of the nominees have carried on some entomological research, and are members of the Entomological Society of America although their interests were primarily in zoological studies rather than in applied entomology. The others were all outside the field of entomology. Both those interested in entomology were elected: Dr. Alfred Emerson of Chicago, chairman, and Dr. Orlando Park of Northwestern, member of the executive committee. Dr. Emerson is interested in termites; Dr. Park, in Pselaphid beetles.

The present executive committee consists of Professor Carl G. Hartman of Illinois, chairman; Professor J. W. Buchanan of Northwestern, secretary; Dr. A. C. Kinsey, Indiana; Dr. C. L. Turner of Northwestern; Dr. Charles W. Metz of Pennsylvania; and Dr. Franz Schrader of Columbia University.

All are members of the American Society of Zoologists and all but one are also members of the American Society of Naturalists. Several are also connected with genetic organizations. One, Dr. A. C. Kinsey is a member of both the American Association of Economic Entomologists and of the Entomological Society of America, was a vice president of that Society in 1937, and has repeatedly attended the meetings of this Association before the war. Dr. Kinsey's four-year term is now expiring and as mentioned above Dr. Park has been elected in his place.

It would thus appear that the Section has for some years included on its executive committee men interested in insects and insect control and members of both national entomological organizations.

It still remains true, nevertheless, (1) that the executive committee tends to be self-perpetuating, instead of including representatives chosen by the constituent societies, and (2) that several of the constituent organizations in Section F (especially the mammalogists and parasitologists) have not been represented recently on the executive committee.

Our recommendations this year accordingly reiterate to a large extent those made at the New York meeting and are as follows:

(1) That the councilors of this association strive to attend not only all the meetings of the AAAS council but also the business meetings of Section F.

(2) That we reaffirm our desire to take a more active part in the affairs of the AAAS and the Section.

(3) That we suggest to the officers of Section F that they solicit nominations for Section officers each year from the specialized societies affiliated with the Section. The new officers would then be elected by the entire Section Committee from among such nominees.

(4) That we continue to nominate three councilors for the two positions available to us on the council as we did last year designating the carry-over names as the official councilors and the most recent designee as the alternate.

Your councilors expect to make every effort to attend the St. Louis meeting of the AAAS in March

and will try to carry out whatever policy this Association desires.

In addition to our correspondence and conversations on organization problems with the officers of the AAAS, referred to in the preceding sections of this report, your councilors were each asked to reply to a long questionnaire concerning our opinions on controversial features of the Science Foundation bills now pending in Congress. The replies from all of those addressed were summarized by the executive secretary of the AAAS and submitted to the Congressional Committee conducting hearings on the subject. This summary has been published in *Science*.

In this correspondence we stated the feelings of entomologists in these words, "We wish to be certain of two features under the science Foundation bills: (1) assurance of the appointment of competent entomologists on any administrative committees handling entomological problems, and (2) relieving such a Foundation from any authority over the internal administration of the research work of the established government departments."

We hope that the relationships of this Association to the AAAS will be discussed at the Dallas meeting in order that the councilors may have the consensus of opinion of the membership on the problems involved.

F. L. CAMPBELL S. B. FRACKER
ROGER C. SMITH

REPORT OF THE CROP PROTECTION INSTITUTE

The volume of research administered by the Crop Protection Institute in 1945 was similar to that of 1944. Ten organized projects were underway in the course of the year, and in addition, several preliminary investigations were undertaken. In the latter part of the year, with the close of the war, an increase in research activities began to manifest itself. There are indications that 1946 will see an increase both in the number of industrial laboratories that call upon the Crop Protection Institute to conduct research for them, and in the total volume of research as expressed in appropriations made available.

The year 1945 has seen a marked emphasis on chemical exploration in both insecticides and fungicides. The purely chemical aspects are largely the function of industrial chemical laboratories which possess both the facilities and the background of knowledge on which intelligent exploration should be based. Study of new compounds from a biological aspect is the function of men who are trained in biological appraisal, usually in the appropriate federal bureaus and in the state agricultural experiment stations. The function of the Crop Protection Institute in this picture is to administer funds provided by industrial laboratories, through cooperation with experiment stations and biological research institutions.

In 1945 the major projects administered by the Institute included the following:

Tenacity agents for sprays and dusts.
Metal amines as fungicides.
Chromates as insecticides and fungicides.
Baits for ants.
New organic compounds as insecticides and fungicides.
Celites as extenders for derris powder and for calcium arsenate.
New poly chlor compounds as insecticides.
Seed and soil treatment.
Stability of organic fungicides.
Efficiency of an organic by-product fertilizer.

Companies supporting organized research through the Crop Protection Institute, in 1945 were:

Animal Trap Company of America.
Armour & Company.
Carbide and Carbon Chemicals Corporation.
General Chemical Company.
Johns-Manville Corporation.
The Mathieson Alkali Works, Inc.
Röhm & Haas Company.
U. S. Industrial Chemicals, Inc.

In addition, preliminary work was carried on for the following:

J. T. Baker Chemical Company.
Battelle Memorial Institute
Fritzsche Brothers, Inc.
The Texas Company.

Research workers and assistants employed by the Institute in 1945 included the following:

C. C. Alexander, Raymond W. Barratt, Asher Capelle, Donald P. Connola, David J. Doerfler. George R. Ferguson, John B. Harry, David Laddey, Wallace J. Morse, Limon C. Murphree, Howard W. Smith, Audrey M. Bill, Clare Chaplinski, Edith J, Converse, Mary B. Fetherston, Geraldine F. Mason. Winifred Musch, Gloria G. Shanley, Dolores M. Smith, Margaret B. Steinmetz.

W. C. O'KANE

REPORT OF JOINT COMMITTEE ON MILITARY ENTOMOLOGY

During the past year the joint Committee on Military Entomology of the American Association of Economic Entomologists and the Entomological Society of America has had less opportunity than during previous years of the war to assist actively in the placement of entomologists in appropriate position in the military services. The needs of the services for entomologists had been met largely in preceding years and changes were effected through promotion rather than through procurement.

The records of entomologists carrying on work in their own field in the armed services are not available in up-to-date or complete form but they indicate that nearly 600 men who might be classified as entomologists were so engaged. In the Army these men served mainly in the Sanitary Corps, the Corps of Engineers, the Typhus Commission of the U.S.A., the Chemical Warfare Service and in Military Administration. In the Navy they were mostly in the Hospital Volunteer Corps Service.

The approximate number of entomologists of various commissioned ranks in the Sanitary Corps was: 5 2nd Lieutenants, 102 1st Lieutenants, 95 Captains, 30 Majors, 6 Lt. Colonels, and 2 Colonels; in the H.V.C.S. of the Navy, 19 Ensigns, 48 Lieutenants Jr. Grade, 36 Lieutenants, 10 Lt. Commanders and 3 Commanders.

We regret to report that at least two entomologists lost their lives in the discharge of entomological duties. These were:

Lt. Wm. M. Gordon, H-(V)S, USNR, March 7, 1944, Los Negros Island, Admiralty Group.

Lt. John D. Maple, H(S) USNR, April 11, 1945, Okinawa, Japan.

The rather extensive personnel files relating to

entomologists of military age and others have been made available to the Committee on Reemployment and Placement as an aid to the development of complete files. To aid in the Associations' replacement work your Committee suggests to the Executive Committee of the Association that steps be taken in connection with the proposed mail ballot to obtain information from each member as to whether he served in the armed forces or otherwise contributed directly to the war effort, and in what capacity.

The work of the entomologists has been so outstanding in the field of research connected with the development of entomological information for direct use in war operations and in reduction of that information to actual practice that several military citations have been made in the entomological field. The Committee is endeavoring to aid the military authorities in bringing to attention other such outstanding accomplishments so that they may receive appropriate consideration by military authorities.

Entomology and entomologists have made notable contributions toward the winning of the war and entomologists have played a prominent part in applying their knowledge in the protection of health and efficiency of troops, in the protection of food supplies and in the protection of these supplies and of equipment from destruction by insects. We may well feel proud of that record. Even though it will be perpetuated in the history of the war now under preparation, it seems eminently fitting that a committee be appointed to prepare and arrange for publication a history of entomologists and their efforts toward the winning of the war. It is recommended that the Committee on Military Entomology be discharged.

ROBERT MATHESON
F. C. BISHOPP, *Chairman*

REPORT OF THE JOINT COMMITTEE ON COORDINATION OF ENTOMOLOGY WITH THE WAR EFFORT

To the President and Executive Committee of the American Association of Economic Entomology and of the Entomological Society of America, respectively:

Your committee has been inactive during the year in so far as formal meetings and modifications of the program heretofore reported are concerned.

The original charter of the committee charged it with the duty of directing the resources of the entomological profession into those channels where entomology should most effectively promote the over-all war effort of the nation.

Inasmuch as the activities associated with the placement of entomologists in the armed forces where their training and abilities could be most effectively utilized were very properly delegated to a special committee, the Coordination Committee had no direct part in that work. Your committee did, however, maintain the position that the members of the entomological profession as a group should not be given preferential treatment with respect to induction into the armed services on the grounds that they were needed at home. This was because of a strong conviction, amply supported by subsequent events which are now history, that entomologists could be even more valuable in the armed forces than at home.

The committee dedicated the entomological profession to the pledge that those members who, for one reason or another, were not qualified for military service increase their efforts, both individually and cooperatively, to the end that national health be maintained and that losses from insect pests in food production be reduced to the lowest possible level.

The earliest and most important action of your committee was to inaugurate a comprehensive plan for cooperation among entomologists and with other agencies and industries. To this end a carefully chosen system of committees and sub-committees was set up. Entomologists from all over the country were given specific assignments which were carried out far beyond the expectations of the parent committee. Indeed, abilities and skills were discovered which previously were not known to exist.

From time to time, minor changes were made in the first formal organization of the committee's overall plan but these were relatively few.

The last assembly of the committee was held December 1944 in connection with the New York meetings of the American Association of Economic Entomologists and the Entomological Society of America. Because of the trend the war took early this year and because the existing program was operating smoothly, there seemed no justification to call the committee together in 1945. However, the committee was willing to continue to serve when requested to do so by Presidents Van Dine and Rehn, and to stand by for any emergency that might arise.

In view of the significant service that entomology contributed in winning the war, your committee recommends that the officers and Executive Committees of the American Association of Economic Entomologists and of the Entomological Society of America give serious consideration to the advisability of assembling and publishing an historical record of the service rendered by entomology in all its phases during the course of all those phases of entomology which were concerned directly with the war effort.

Finally, not as a committee, but in the name of entomology in general, we commend entomologists for the part played by our profession in World War II. Especially do we salute those who served in the armed forces. We cannot help but be proud of the fact that among our number is found one of the most decorated men in the service.

D. L. Van Dine, *ex officio*
J. A. G. Rehn, *ex officio*
E. N. Cory
L. M. Peairs
S. A. Graham
Avery S. Hoyt
E. F. Phillips
A. Glenn Richards
P. D. Sanders
J. S. Houser, chairman

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